THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE AND RURAL ECONOMY

PARASITIC FUNGI ON GRAIN CROPS

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1. Blade of wheat attacked by rust.
2. Portion of blade of wheat (magnified), showing the first stage of growth of rust called *Uredo.*
3. Section of leaf, showing uredospores protruding from leaf and threads of fungus (hyphæ) feeding on cells of leaf.
4. Uredospores germinating and commencing to form the threadlike body (hyphæ).
5. A Barberry leaf, showing the second stage in the life history of the rust (*Æcidium*).
6. A transverse section of Barberry leaf (lower side uppermost), showing the diseased portion of leaf specially thickened with a cup-like *Æcidium* full of round spores.
7. Another stage in life of rust of wheat (*Puccinia*), showing the two celled resting spores

7a. Three of the resting spores—two in the process of germination.

7b. A portion of leaf, showing clusters of *Puccinia.*

8. Ear of oat attacked by smut (*Ustilago*).
9. Single spikelet of oat (magnified) attacked by *Ustilago.*
10. Dark spores of smut (magnified).

10a. Same with spores germinated, ready to attack oat.

11. Ear of wheat attacked by Bunt (*Tilletia*).
12. Single spikelet of wheat (magnified) attacked by *Tilletia.*
13. Four of netted spores (highly magnified).
14. Section of grain of wheat, filled with dark spores.

THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE AND RURAL ECONOMY

BY THE MOST DISTINGUISHED
AUTHORITIES AND SPECIALISTS
UNDER THE EDITORSHIP OF

PROFESSOR SIR ROBERT PATRICK WRIGHT

F.H.A.S., F.R.S.E., AGRICULTURAL ADVISER TO THE SCOTCH
EDUCATION DEPARTMENT, FORMERLY PRINCIPAL OF THE
WEST OF SCOTLAND AGRICULTURAL COLLEGE, GLASGOW

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LIST OF PLATES

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LIST OF CONTRIBUTORS

VOLUME XI

The contributors sign by their initials at the conclusion of their respective articles. Those in the present volume are as follows:—

A. H.	**A. Hosking**, Instructor in Horticulture in the West of Scotland Agricultural College; Author of "The Teaching of Gardening in Schools and the Formation of School Gardens".
A. L.	**Alexander Lauder**, D.Sc., Lecturer in Agricultural Chemistry, East of Scotland Agricultural College; Hon. Consulting Chemist to the Royal Scottish Arboricultural Society; Author of "Variations in the Composition of Milk".
A. M.	**Alfred Mansell**, Breeder and Judge of Shropshire Sheep; Secretary to the Shropshire Sheep-Breeders' Association; Correspondent to the Board of Agriculture; Author of article "Shropshire Sheep".
A. M.	**Alex. Main**, B.Sc., N.D.A., Lecturer in Agriculture, West of Scotland Agricultural College.
A. N. M'A.	**A. N. M'Alpine**, B.Sc.(Lond.), Assoc.R.C.S., Professor of Botany, West of Scotland Agricultural College, Consulting Botanist to the Highland and Agricultural Society of Scotland; Author of "A Botanical Atlas", &c.
C.	**The Right Honourable Earl Carrington**, K.G., P.C., G.C.M.G., President of the Board of Agriculture.
C. C.	**Charles Crowther**, M.A.(Oxon.), Ph.D., Lecturer on Agricultural Chemistry, Leeds University; Author of "Milk Investigations at Garforth", &c.
C. M. L.	**Charles M. Luxmoore**, D.Sc.(Lond.), F.I.C., F.C.S., Principal, Central Technical Schools for Cornwall, Truro; Author of "The Soils of Dorset", "The Hygroscopic Capacity of Soils", &c.
C. W.	**Cecil Warburton**, M.A., F.Z.S., Zoologist to the Royal Agricultural Society of England; Author of "Orchard and Bush Fruit Pests", &c.

C. W. S.	**Charles W. Sleigh,** M.A., J.P., Estate Factor and Valuer, Secretary and Treasurer to the Scottish Estates Factors' Society, and Editor of its Magazine.
D. B.	**David Bruce,** M.A., LL.B., Lecturer in Agricultural Law, West of Scotland Agricultural College.
D. H.	**D. Houston,** F.L.S., Royal College of Science, Dublin.
D. K. R.	**Daniel K. Robb,** F.H.A.S., N.D.D., Superintendent of the West of Scotland Agricultural College Experiment Station, Kilmarnock.
E. B.	**Edward Brown,** F.L.S., Lecturer on Poultry at the University College, Reading; Secretary of the National Poultry Organization; Author of "Poultry-keeping", &c.
E. J. R.	**Edward John Russell,** D.Sc.(Lond.), F.C.S., Chemist for Soil Investigation at the Rothamsted Experimental Station, Harpenden.
F. B. S.	**F. B. Smith,** F.S.I., Director of the Transvaal Department of Agriculture; Author of "Agriculture in the New World", &c.
F. H. A. M.	**Francis H. A. Marshall,** M.A.(Cantab.), D.Sc.(Edin.), Lecturer in Agricultural Physiology in the University of Cambridge.
F. S.	**Fred. Smith,** Secretary to the Suffolk Horse Society.
F. V. T.	**F. V. Theobald,** M.A.(Cantab.), Vice-Principal and Zoologist at the South-Eastern Agricultural College, Wye, Kent; Author of "A Textbook of Agricultural Zoology", "Reports on Economic Zoology", &c.
G. A. J. C.	**Grenville A. J. Cole,** F.G.S., Professor of Geology in the Royal College of Science, Dublin; Director of the Geological Survey of Ireland; Author of "Aids in Practical Geology", &c.
G. N. K.	**G. N. Keller,** Tobacco Expert to the Department of Agriculture for Ireland.
G. W.	**Sir George Watt,** M.B., C.M., F.L.S., LL.D., Kew, London; Author of "Economic Products of India", &c.
H. B.	**Harry Bamford,** M.Sc., A.M.I.C.E., Lecturer on Agricultural Engineering, West of Scotland Agricultural College.
H. L.	**Harold Leeney,** M.R.C.V.S., Author of "Home Doctoring of Animals", "The Lambing Pen", &c.
H. S. H. P.	**H. S. Holmes Pegler,** Secretary of the British Goat Society; Author of "The Book of the Goat".
H. S. R. E.	**Hugh S. R. Elliot.**
J. A. T.	**J. Arthur Thomson,** M.A., Professor of Natural History, Aberdeen University, Examiner in Agricultural Zoology for the National Diploma in Agriculture; Author of "Heredity", &c.
J. A. V.	**J. Augustus Voelcker,** Ph.D., M.A., B.Sc., F.I.C., &c., Consulting Chemist to the Royal Agricultural Society of England.
J. B.	**John Brown,** B.Sc., N.D.A., Organizer of Agricultural Instruction, South Canterbury, New Zealand.

J. C. E. **J. Cossar Ewart**, M.D., F.R.S., Regius Professor of Natural History, Edinburgh University; Author of "The Penycuik Experiments", &c.

J. C. N. **J. C. Newsham**, Principal of the Farm School, Basing, Basingstoke.

J. Gl. **John Glaister**, M.D., Professor of Medical Jurisprudence and Public Health in the University of Glasgow.

J. G. M'P. **Rev. J. Gordon M'Pherson**, M.A., Ph.D., F.R.S.E., Lecturer on Meteorology to the University of St. Andrews; Author of "The Fairyland Tales of Science", &c.

J. Go. **John Golding**, F.I.C., F.C.S., Head of the Chemical and Bacteriological Departments at the Midland Agricultural and Dairy Institute, Kingston, Derby.

J. H. **James Hendrick**, B.Sc., F.I.C., F.C.S., Lecturer in Agricultural Chemistry in the Aberdeen University, Chemist to the Highland and Agricultural Society of Scotland, Analyst to the Counties of Aberdeen, Banff, and Nairn.

J. K. **James Knight**, M.A., D.Sc., F.C.S., Author of "Food and its Functions", &c.

J. Lo. **James Long**, formerly Professor of Dairying and Farming, Royal Agricultural College, Cirencester; Author of "British Dairy Farming", "Elements of Dairy Farming", &c.

J. M'I. **James M'Intosh**, N.D.A.(Hons.), N.D.D., C.D.A.D., Lecturer in Agriculture and Dairying, South Eastern Agricultural College, Wye, Kent.

J. N. **John Nisbet**, D.Œc., Professor of Forestry, West of Scotland Agricultural College; Editor of *The Forester*, Author of "Studies in Forestry", "British Forest Trees", &c.

J. P. **John Percival**, M.A.(Cantab.), F.L.S., Professor of Agricultural Botany, University College, Reading; Author of "Agricultural Botany", "Agricultural Bacteriology".

J. R. A. D. **J. R. Ainsworth Davis**, M.A., F.C.P., Principal of Royal Agricultural College, Cirencester; Author of "The Natural History of Animals".

J. R. M'C. **John R. M'Call**, M.R.C.V.S., Professor of Pathology and Meat Inspection, Glasgow Veterinary College.

J. S. **John Speir**, Kt.St.Olaf, Newton Farm, near Glasgow, Member of the Royal Commission on Tuberculosis, 1897; Author of "Report on Milk Records".

J. W. **James Wyllie**, B.Sc., N.D.A.(Hons.), N.D.D., C.D.A., Lecturer in Agriculture, West of Scotland Agricultural College.

J. Wr. **John Wrightson**, late Principal of Downton Agricultural College; Author of "Farm Crops", "Sheep Breeding and Feeding", &c.

M. B. **Miles Benson**, Manager and Chief Instructor in Dairying, British Dairy Institute, Reading.

R. A. B.	**Reginald A. Berry**, F.I.C., F.C.S., Professor of Agricultural Chemistry in the West of Scotland Agricultural College; Joint Author of "Soil Analysis", "Selection of Seed by Chemical Methods", &c.
R. B. G.	**R. B. Greig**, F.H.A.S., F.R.S.E., Lecturer on Agriculture, Aberdeen and North of Scotland Agricultural College.
R. H.	**Richard Henderson**, Lecturer on Surveying in the West of Scotland Agricultural College; Author of "The Young Estate Manager's Guide", "The Modern Homestead", &c.
R. H. L.	**Renwick Hutson Leitch**, M.A., B.Sc., N.D.A.(Hons.), N.D.D., Lecturer in Agriculture in the West of Scotland Agricultural College.
R. H. R.	**R. H. Rew**, Head of the Statistical Department, Board of Agriculture.
R. I. P.	**R. I. Pocock**, F.L.S., F.Z.S., Superintendent of the Zoological Society's Gardens, Regent's Park, London.
R. P. W.	**Sir Robert Patrick Wright**, F.H.A.S., F.R.S.E., Agricultural Adviser to the Scotch Education Department; formerly Principal of the West of Scotland Agricultural College.
R. W.	**Robert Wallace**, Professor of Agriculture, Edinburgh University; Author of "Farm Live Stock of Great Britain", &c.
S. R. S.	**Samuel R. Sherwood**, Breeder of Suffolk Sheep; Member of Council of the Suffolk Sheep Society.
S. S.	**Sanders Spencer**, Holywell Croft, St. Ives; Author of "Pigs for Breeders and Feeders", "Pigs, Breeds and Management".
T. H.	**T. Hallissy**, B.A., of the Laboratory for the Investigation of Soils, Geological Survey of Ireland.
V. S.	**Vero Shaw**, Author of "How to Choose a Dog", "Don'ts for Dog Owners", &c.
W. A. T.	**W. A. Thain**, A.M.I.C.E., Professor of Land Surveying and Estate Engineering, Royal Agricultural College, Cirencester.
W. B.	**William Barber**, M.A., Tererran, Moniaive.
W. E. B.	**W. E. Bear**, formerly Editor of *Mark Lane Express*.
W. G.	**Sir Walter Gilbey**, Bart., D.L., J.P., Past President of the Shire Horse Society, Member of the Royal Commission on Horse Breeding; Author of "Riding and Driving Horses", "Horses Past and Present", "Thoroughbred and other Ponies", &c.
W. G. S.	**William G. Smith**, B.Sc., Ph.D., Lecturer in Agricultural Botany, East of Scotland Agricultural College, Edinburgh; Translator of Tubeuf's "Diseases of Plants".
W. J. M.	**Walter J. Malden**, late Principal, Agricultural College, Uckfield; Author of "Tillage and Improvements", "Up-to-Date Farm Implements", &c.

W. Sou. **W. Southworth,** N.D.D., F.L.S., late Lecturer on Agricultural Botany and Entomology, Uckfield Agricultural College.

W. St. **William Stevenson,** B.Sc., N.D.A., N.D.D., Lecturer on Dairying in the West of Scotland Agricultural College; Author of "Culture Starters in Dairying".

W. W. **William Watson,** A.L.S., Curator, Royal Gardens, Kew; Editor of "The Gardener's Assistant".

W. W. C. **Walter William Chapman,** F.S.S., Secretary to the National Sheep-Breeders Association.

The classic series of articles on insects by the late John Curtis have been embodied in the work, revised by Professor F. V. Theobald and Mr. Cecil Warburton, M.A., and bear the initials of J. C. and F. V. T. or C. W.

In like manner the great botanical articles of the late Professor John Lindley, which, like Curtis's articles above-mentioned, were contributed to Morton's *Cyclopedia of Agriculture*, have, under Professor A. N. M'Alpine's revision, been embodied over the initials J. L. and A. N. M'A.

THE STANDARD CYCLOPEDIA OF MODERN AGRICULTURE

Shropshire Sheep.—ORIGIN AND HISTORY.—There is a general consensus of opinion that this breed is descended from the Morfe Common sheep in Shropshire and the Cannock Chase breed in the neighbouring county of Staffordshire. Morfe Common, near Bridgnorth, occupied an area of about 4000 ac. on the borders of the River Severn; and Professor Wilson, in his report of the breeds in the Journal of the Royal Agricultural Society, vol. xvi, states that when the Bristol Society in 1792 procured as much information as possible regarding sheep in England, they reported as follows in reference to Morfe Common sheep: 'On Morfe Common, near Bridgnorth, there are about 10,000 sheep kept during the summer months, which produce wool of a superior quality. They are considered a native breed, are blackfaced, or brown, or spotted-faced horn sheep, little subject to either rot or scab, weighing, the wethers from 11 to 14 lb., and the ewes from 9 to 11 lb. per quarter, after being fed with clover and turnips, and clipping near 2 lb. per fleece. This appears to be the original stock from which the present breed of Shropshire sheep has sprung.'

Smith, in his history of wool and woollen manufactures (Chron. Rusticum, published 1641), quotes the wool of Shropshire as being the *choicest and dearest in England*; and this is confirmed by Anderson in his Origin of Commerce, giving prices for English wool in 1343. Cannock Chase, in Staffordshire, an enclosed common, was also the habitat of a very similar and equally valuable race of a somewhat heavier type, from which many of the best flocks in Staffordshire were originally descended.

Though some few writers state that the Southdown was used in the first attempt at improvement of the breed, and to effect the removal of the horns, many men equally well qualified to give an opinion, adhere to the statement that the present uniformity of character and perfection of form is the result of selection from home-bred sheep of the best type. There appears to be no doubt that some breeders, many years ago, had recourse to the Southdown; but whether Southdown or other rams have been introduced is a matter of small moment. One thing is certain, that no one during the last sixty years, who has obtained any success as a breeder of Shropshires, has deviated from a line of pure breeding. By careful selection and judicious mating of its own species the Shropshire sheep has been brought to the leading position it now occupies. The best characteristics of the breed were present when the work of improvement began. It has been by developing the strongly inherited characteristics of the native breed of the district that all the best flocks have been built up.

The public appearance of the breed in the 'Royal' show yard at Gloucester in 1853 was the turning-point with the Shropshire sheep, and encouraged breeders to use their best judgment in selection, and to do all in their power to place their breed of sheep in the front rank. Shropshires were next seen at the Great National Show in 1857 at Salisbury, and again in 1858 at Chester. Mr. Millward, in his report in the Royal Journal of the latter year, states that 'the new class of Shropshires (184 animals) was very successful'; but it was not until the Warwick meeting, the following year (1859), that special classes for the breed were admitted into the Royal Agricultural Society's prize sheet. One hundred and ninety-two Shropshires were there exhibited. Since then they have considerably increased in numbers at the 'Royal' shows, culminating in the grand display at Shrewsbury Royal Show in 1884, when 875 Shropshires were exhibited, against 420 of other distinct breeds, being considerably *more than double the number* of sheep of all other breeds, and demonstrating very conclusively that the Shropshire is a sheep which best meets the requirements of the present day.

So far back as 1861 one of the Shropshire sheep judges at the Leeds exhibition gave the following report: 'Perhaps no description of sheep excited more interest in the show yard than these. Here we find them in greater number than any other breed of sheep shown. It is impossible not to be struck with the appearance of these as a most useful rent-paying kind of animal. It would be well for the breeders of these sheep to bear in mind that qualities which have brought their sheep into notice are their aptitude to produce great weight and quality of both mutton and wool, combined with early maturity, whilst they will bear to be stocked more thickly than any other breeds of equal weight. In addition to these good qualities they are far more prolific than any other breeds, and capital nurses.'

In describing what a Shropshire sheep should be, one cannot do better than give the points

which were chiefly considered by three eminent men who acted as judges at the Birmingham 1876 meeting of the Royal Agricultural Society of England. They say that they selected for prizes those animals which they considered best calculated to uphold and perpetuate the most distinctive type of the Shropshire, namely, a well-developed head, with clear and striking expression of countenance; a muscular neck, well set on good shoulders; the body symmetrical and deep, placed as squarely as possible on short legs; due regard being paid to a grandeur of style, a well-covered head, and wool of the best staple and most valuable kind. A rider to this description should state that the skin should be a nice cherry colour, and the face and legs of a nice soft black—not sooty, nor a rusty brown—and free from all white specks. The belly should also be well woolled.

Some farmers prefer a big coarse sheep on long legs, but the most rent-paying class is the moderate-sized sheep of good quality, because the butchers can sell them more readily and at better prices, and a greater weight per acre can be raised than where the larger and coarser sheep is resorted to, as 100 ewes in the former instance require as much land for their support as 120 well-bred moderate-sized ewes.

POINTS.—*Prolific Character.*—150 to 175 lambs per 100 is the usual average. 11,666 ewes in 1896 reared 168 lambs per 100 ewes.

The Ewes Good Mothers.—Shropshire ewes are excellent nurses, and nature has endowed them with great milk-yielding properties.

Wool.—An average weight of fleece for a whole flock would be 7 to 8 lb.; individual fleeces often attain 16 to 18 lb. The Shropshire sheep cuts a heavy fleece of wool of the most marketable description, being of good staple, fine in texture and very dense, with small loss in scour, and is always readily saleable. Ram and ewe tegs would average quite 10 lb. of washed wool, and a fair average for a whole flock would be 7 to 8 lb.

Adaptability to Various Soils and Climes.—The most ubiquitous sheep extant, in every county in England the Shropshire sheep flourishes, also in the northern parts of Scotland, the humid climate of Ireland, and the mountainous districts of Wales, frequently at an altitude of 1000 ft. above sea level; and also thrives and does well in the United States, Canada, South America, Russia, France, Germany, the Australian Colonies, South Africa, Jamaica, and the Falkland Isles, and indeed in every part of the world.

Early Maturity.—If well cared for, the wethers are fit for the butcher at ten to twelve months old, and that on a moderate consumption of food. Shropshire lambs mature very early as fat lambs, and the Shropshire cross for the fat-lamb trade cannot be beaten.

Constitution and Hardihood.—The breed is notoriously sound in constitution, and capable of standing extreme variations of heat and cold, and is one of the most hardy breeds in existence. The writer well remembers seeing a Shropshire ewe nineteen years old, hale and hearty, having reared thirty-three lambs, and herself enjoying an absolute and life-long immunity from footrot.

Quality of Mutton.—The mutton of the Shropshire is rich in flavour, close in grain, juicy, and contains a large percentage of lean meat, and commands the highest price in the London, Manchester, Liverpool, and all the principal markets of Great Britain. Again, the Shropshire of the present day has all the quality of the Southdown, with considerably more size; it carries a large proportion of lean meat to fat, is light in offal, and with good management it comes to market at ten to twelve months old, weighing 18 to 22 lb. per quarter, in some instances attaining even greater weights. Wethers at eighteen to twenty months old at the Birmingham Fat Show often attain 50 lb. per quarter, and ewes have been exhibited over 46 lb. per quarter.

Docile Character and Economic Consumers.—The Shropshire is a placid and contented animal, not given to roaming and trampling down pasturage, and has the special aptitude to make the best of the food at hand, and to produce mutton at a minimum of cost.

General-purpose Sheep.—Shropshire sheep have rapidly increased in favour in all parts of the world; and combining as they do the most desirable points (from a wool and mutton point of view) to a greater extent than any other breed, with the minimum of objectionable features, they have attained an eminent and permanent position in the estimation of sheep-breeders all over the world. In fact they meet all the requirements of the present day as a successful general-purpose sheep, and are therefore very profitable to farmers and graziers. The Shropshire has been largely bred for crossing purposes to produce 'freezers', with splendid results.

MANAGEMENT.—The following is a short epitome of the general management of Shropshire flocks. The ewes are put to the ram so as to drop their lambs in February and March. The rams are usually run out with the ewes, except in the case of a valuable animal, when sometimes a teaser is used, and the ewes as they come on are brought to the ram. Flushing the ewes is a general practice, either on second year's seeds or a fresh pasture. An average of about fifty ewes to each ram is the rule. Shearling or older rams generally do service, and ram lambs are not greatly used, except in cases where ewes have turned several times and the season is advancing. From this period to lambing time the ewes are run on old seeds or pastures, and, as the season advances, are assisted with long hay and a few roots. When lambing commences they are folded at night. The ewes and lambs are kept in for a day or so, and receive a few oats, bran, cut roots, and a little hay, and then to the young seeds or a fresh pasture. Only the ewes with twins get any assistance, except perhaps a few lambs for show purposes. Oats and bran is the usual diet, with perhaps a little good linseed cake. The lambs' ears are all punched numerically for the purpose of keeping correct pedigrees, and when any of them are passed into the breeding flock, metallic ear tags are used. These ear tags are very neat and light, and remain safely in the ear for a long time.

Castration is not a general practice, the pro-

ess of selection being generally left to the winer, when the inferior rams are fed and sold to he butcher.

Shearing the lambs is now a general practice, nd takes place in June. It gives greater imnunity from the fly, and prevents the clinging f the soil to the belly when on turnips. The ambs are usually weaned at the end of May or arly in June, and divided into sexes and put on fresh pastures, and get a little artificial assisance; and as soon as available they get a few ommon turnips thrown upon the ground, and his, with the assistance of vetches, rape, kale, nd cabbage, carries them to September, and as he harvest fields are cleaned, the young seeds re made use of. From thence to early spring he young sheep are folded on common turnips, ale, and swedes, with the assistance of a mixed rtificial diet, and by January and February the ull rams are ready for the knife. The rams nd ewes intended for show and sale are kept on the turnips a little longer, and those intended for show are housed and pushed on as much as possible.

With the exception of the sheep intended for exhibition purposes, it is the more general custom to treat the majority as pasture rangers, as it is found in practice they are more reliable stock getters than those which have been housed, fed, and are unduly fat.

Markets: Average and Record Prices.—The chief markets are Shrewsbury, Lichfield, Birmingham, and Stafford, where sales are annually held in the months of August and September; and of late years very successful sales have taken place at the annual meeting of the Royal Agricultural Society, usually held about the third week in June. To give anything like a full list of good averages made at sales, or individual prices, is beyond the scope of this article, but the following are selected as authentic and representative:—

			Highest Price.	Average.
1878	Lord Chesham	63 rams	94 gs.	£20 10 6
1881	T. J. Mansell	25 ,,	200 ,,	36 16 6
1882	T. J. Mansell . . .	30 ,,	200 ,, (let)	37 16 6
1890	W. F. Inge . . .	37 ,,	150 ,,	32 9 10
1895	A. E. Mansell ...	45 ,,	230 ,,	41 16 6
1901	A. E. Mansell (disp. sale)	61 ,,	400 ,,	33 8 8
		205 ewes	13 ,,	5 7 6

Individual Prices at which Shropshire Rams have been Purchased or Hired

		Guineas.
G. Graham	Nottingham Royal .	200
A. E. Mansell	Double First ..	200
A. E. Mansell	Ruddington Eclipse	230
D. Buttar	Royal Record ...	310
A. E. Mansell	Royal Blood	240
Sir R. P. Cooper's	Ram . . .	240
A. E. Mansell .	Lord Cardiff	400
	Dudmaston Hero .	200
	Pride of Bristol ...	200
	Shropshire President	200
	The Patriot (to serve 50 ewes) (let) .	200
	The Rector (20 ewes to go with him) (let) ..	210

Chief Flocks and Breeders.—The followng is a brief selection of the more important ierds of Shropshire sheep:—

The Packington Hall flock of Shropshires, the roperty of Mr. Joseph Brown, descended from he old-established Cannock Chase flock. About 0 rams are annually sold, and average 7 to 8 gs. ach; 200 ewes are put to rams each year. The Ruyton Towers flock, the property of Mr. J. H. S. Walford, instituted in 1889. The number of reeding ewes is 150, and the herd has enjoyed good export demand for many years past. The ota flock, the property of Lord Barrymore, stablished in the year 1853, and is perhaps the ldest-established flock of Shropshires in Ireland. At present the flock of breeding ewes numbers 50; few ewes or lambs have been sold. The lock has produced many noted prizewinners, nd the highest price obtained for any rams which have been sold is 30 gs. The Alrewas lock, originated by the owner, Mr. J. L. Coxon, in the year 1869. The flock consists of 200 breeding ewes; and though individual specimens have never been exhibited at shows, rams have been sold annually, and have made as high as 70 gs., while ewes have realized about 12 gs. each. The Elford Park flock, founded in the year 1845, and the property of Mr. Charles Coxon. This flock, which at present consists of 150 breeding ewes, has produced many noted prizewinners, and as far back as 1859 a shearling ram, which won the first prize at the R.A.S.E. Show, was sold for 100 gs. Annual sales at home have been held for over fifty years, rams making up to 250 gs., and ewes to 15 gs. each, and in many instances averaging over 5 gs. each for 100 ewes. The Acton Reynold flock, founded in 1901 by Sir Walter Corbet, consists of 120 breeding ewes, and though recently instituted, has been founded on a strain of noted prizewinning Shropshires. Very satisfactory prices have so far been obtained, rams having realized as much as 75 gs., ram lambs 21 gs., and shearling ewes up to 25 gs. The Sutton Maddock flock, the property of Mr. Edward Nock, founded as far back as 1832, consists at present of 200 breeding ewes, and is descended from a strain of noted prizewinning Shropshires. Shearlings from this flock have sold up to 120 gs., ram lambs up to 50 gs., and shearling ewes up to 25 gs. The Shenstone Court flock of Shropshires, founded in the year 1888, has since been consistently improved by the introduction of the very best sires, which have been purchased regardless of cost. A Shenstone ram holds the record for three successive wins at the R.A.S.E. Show, and ewes from the same flock have won first at this show for seven years in succession. Rams of

this flock have realized 240 gs. for export, and as much as 75 gs. has been obtained for ewes. The flock consists of about 400 breeding ewes. The Cahir flock, which numbers at present 150 breeding ewes, belongs to Lady Margaret Charteris, and was founded in 1879. The introduction of blood from noted strains has raised this flock to a high level of excellence. The Wolgarstone flock, the property of Mr. G. Brown, and descended from an old-established strain of Shropshire sheep, includes at present about 140 breeding ewes. Like the last-mentioned, consistent improvement has been made by the introduction of noted prizewinning rams. The Holker flock, owned by Lord Richard Cavendish, was established by the Duke of Devonshire in the year 1897. Specimens of this breed have been exhibited at shows since 1903, and good prices have been realized for shearling ewes and lambs. The present flock consists of 80 breeding ewes. The Corston flock, the property of Mr. T. A. Buttar, founded in 1870, consisting of 260 breeding ewes, has been raised to a high level of excellence by the use of the most successful sires. Noted prices have been obtained for specimens of the flock. In 1897 Buttar Blue fetched 150 gs., in 1898 Royal Record was sold for 310 gs., and in 1900 Record Knight made 130 gs. The Corston flock has taken a preeminent position in the United States and in Canada, sheep bred by Mr. Buttar having won the championship at the Chicago International in 1898–9, and the Toronto Industrial in 1906–7–8. The Lower Eaton flock, owned by Mr. C. T. Pulley, and instituted in the year 1866, embraces 170 breeding ewes, and has been built up by the use of the very best sires purchased from well-known breeders at high prices. A large export trade has been enjoyed for many years, and representatives of the flock have been successfully shown both at home and abroad. The Acton Hill flock of Shropshires, belonging to Mr. R. G. Paterson, was founded in 1894, and at present consists of 170 ewes. The Arbour Farm flock, owned by Mr. J. E. Bourne, originated in 1890, and consists at present of 140 breeding ewes. This flock has had considerable success in the show yard, and commands a good export trade. The Hardwicke Shropshires have been maintained at Hardwicke since 1887. Within recent years the flock has been strengthened by the introduction of several pens of first-class ewes obtained from leading breeders. Great care has been exercised in the selection of sires, with the result that high honours have been obtained in the show yard. A good export trade has been experienced for some years past, many representatives from this flock having secured premier positions at the Chicago International Exhibition and at many of the leading State fairs in the United States. About 190 breeding ewes are kept. The Thorpe Hall flock, which dates back its origin some forty years ago, has been built up by the use of rams of exceptional merit, and ewes purchased at high prices from noted prizewinning strains. The flock, which has enjoyed a very successful show-yard career, consists of 110 to 120 breeding ewes, and has commanded high prices for individual specimens, the ram Doncaster Royal having realized 250 gs. as a four-year-old, and the ram Deemster 190 gs. The Whiston Hall flock of Shropshires, instituted as far back as 1820, is the property at present of Mr. Matthew Williams, and has a foundation stock of 150 breeding ewes. Numerous prizes have been won in the show yard, and rams have been sold for high prices. A representative of this flock won the first prize at the R.A.S.E. Show in 1907, and subsequently realized 250 gs. In 1904 a ram of the Whiston Hall flock was sold at Melbourne for 190 gs. At home the best draught ewes have fetched up to 10 gs., and, in the year 1906, ewes bred at Whiston were sold at Melbourne and made as much as 63 gs. each. The Tern flock of Shropshires, founded in 1862, and at present the property of Mr. T. G. Juckes, consists of 125 to 130 breeding ewes; and though the flock has not been shown, and no high prices made, yet a lot of sheep have been sold to America and have realized satisfactory prices. The Great Chatwell flock of Shropshires, founded in 1860, consisting of 132 ewes, owned by Mr. J. Corden, has long been maintained in a high state of purity. The Shrawardine flock, instituted about eighty years ago, has been represented in the Royal show yard every year since 1858. The flock consists of 120 breeding ewes, and is at present the property of Mr. Alfred Tanner. Many noted prize-winning rams and ewes have been used to build up this flock, and premier honours have been won at the leading shows at home. Finally, there is the Montford flock, founded in 1873, and at present the property of Mr. T. S. Minton. This flock has produced many noted prizewinners. At the annual home sale held in August or September, over 200 gs. has been reached for rams, and 150 gs. for a pen of 5 ewes. The type of Shropshire at Montford is an animal on short legs, with close wool and dark muscular flesh. [A. M.]

Shrubbery.—This term is usually applied to a plantation of shrubs which may or may not also contain plants of a different character, rather than to grounds planted with shrubs here and there. Shrubberies in the past often contained a poor selection of plants, and were consequently gloomy and uninteresting, but of late years they have been improved. A good mixed shrubbery of deciduous and evergreen plants contains a proportion of flowering shrubs, of those with foliage conspicuous in autumn or winter, and of plants with ornamental stems and fruits. It is not a good plan to have bare earth beneath the shrubs. It is much better to carpet the ground with plants that will endure some shade, or in the case of a thin shrubbery, bulbs may be planted. A shrubbery may also be made more attractive by planting a foreground of low-growing perennial flowers. A satisfactory shrubbery cannot be formed under large trees. In planting, it is essential that the most compact-growing and small shrubs should be placed in the front, with those of medium stature next in order, and the largest plants in the middle or at the back. Overcrowding is a common fault, but shrubs may be planted somewhat thickly at first for effect, with a view to the removal of some to

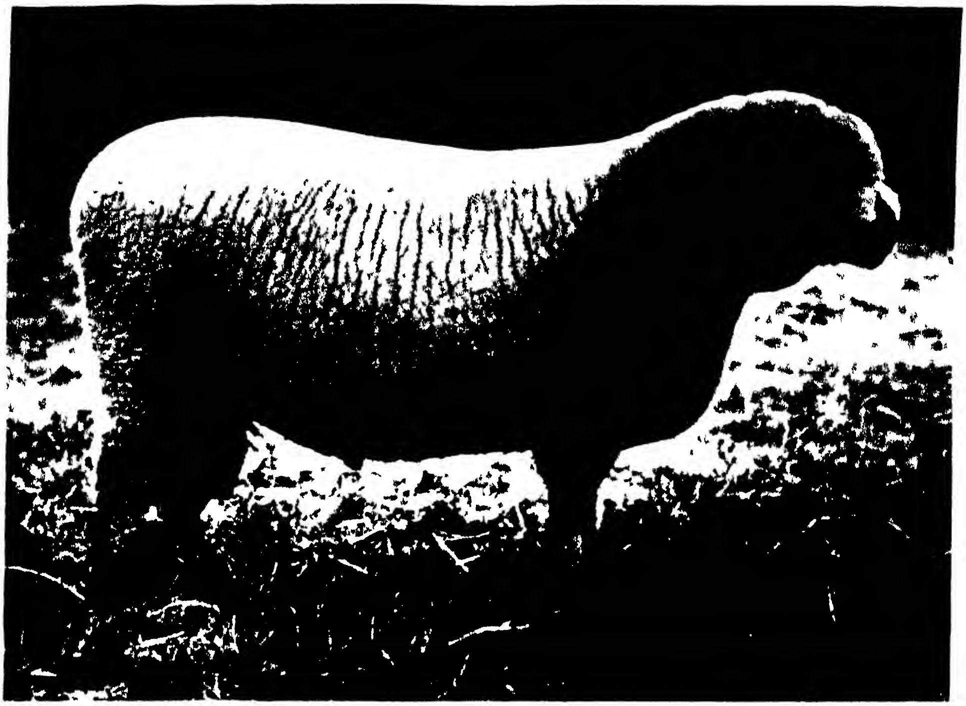


Photo Chas. Reid

SHROPSHIRE SHEARLING RAM

FIRST PRIZE WINNER, R.A.S.E. SHOW, 1908

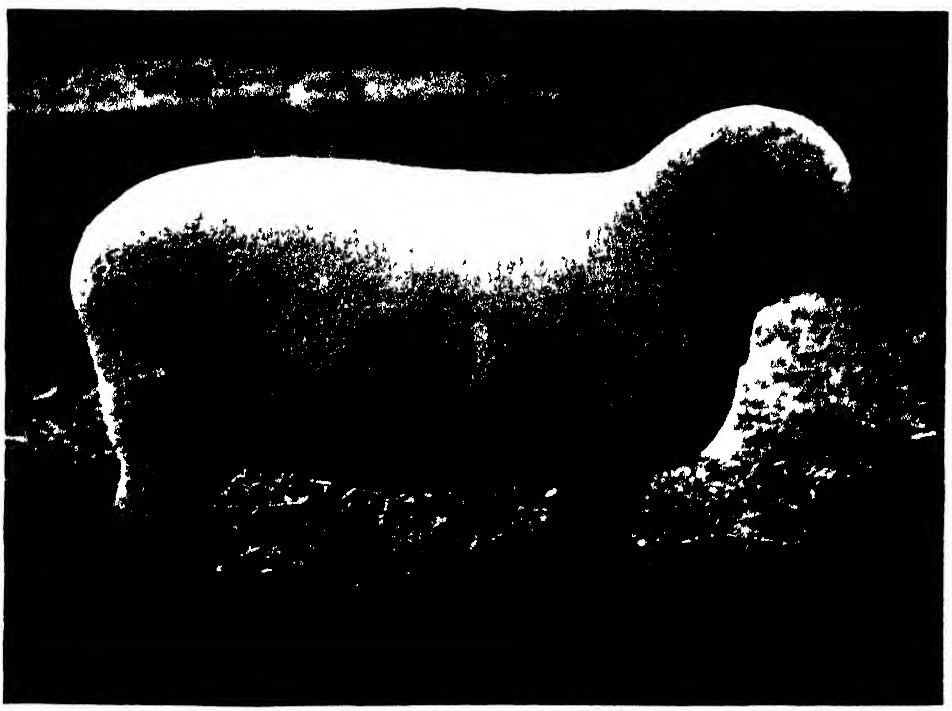


Photo Chas. Reid

SHROPSHIRE EWE

ONE OF CHAMPIONSHIP PEN, R.A.S.E. SHOW, 1908

other quarters when they develop. In mixed shrubberies it is very necessary to see that the strongest-growing plants do not overcrowd their neighbours. [W. W.]

Shrubs. — Flower gardens and pleasure grounds would be poor places without shrubs, and very many gardens would be even more attractive if they contained more of them. In the larger gardens, in addition to the shrubbery proper, it is an excellent plan to plant shrubs, such as free-growing roses, berberises, cotoneasters, philadelphuses, diervillas, &c., in beds, and the effect may be still further enhanced by planting such bulbs as chionodoxas, snowdrops, bluebells, &c., underneath them. Other beds may be planted with evergreen shrubs for winter effect. Most shrubs abundantly repay trouble expended in trenching, manuring, and cultivating the soil, while pruning is also an important matter. Some shrubs, however, such as cytisuses and genistas, will make good growth and flower more freely in comparatively poor soil. Autumn, or, failing that, February, is the best season for transplanting shrubs, but many evergreens may be moved with balls of soil from August till May. Bamboos require to be transplanted in May. It is important that, in transplanting, the roots of shrubs should not be allowed to become dry. The number of good garden shrubs is fortunately very large, and is continually being added to. The following lists will aid those who require to plant shrubs which will thrive under special conditions:

SHRUBS FOR SEASIDE PLANTING

Deciduous

Hippophae rhamnoides.	Lycium europæum and L. barbarum.
Ulex europæus.	Cytisus scoparius.
Tamarix gallica.	Berberis vulgaris.
Myricaria germanica.	Rhamnus catharticus.
Sambucus nigra.	Juniperus communis.
Corylus Avellana.	Ribes sanguineum.
Rosa spinosissima.	Symphoricarpus racemosus.
Rosa rubiginosa.	Ceanothus americanus.
Hydrangea hortensis.	

Evergreen

Euonymus japonicus.	Rhamnus Alaternus.
Veronica decussata	Phillyræa media.
Rhododendrons (thick-leaved kinds).	Phillyræa angustifolia.
Escallonia macrantha.	Phillyræa latifolia.
Escallonia pterocladon.	Cotoneaster microphylla.
Ilex Aquifolium (thick-leaved vars.).	Cotoneaster Simonsii.
Hedera Helix varieties.	Atriplex Halimus.
Quercus Ilex.	Berberis Darwinii.
Cratægus pyracantha.	Berberis empetrifolia.
	Berberis Aquifolium.

EVERGREEN SHRUBS FOR SMOKY TOWNS

Aucuba japonica	Ruscus aculeatus.
Buxus balearica.	Skimmia japonica.
Daphne Laureola.	Ulex europæus.
Osmanthus ilicifolius.	Yucca gloriosa.
Phillyræas.	Yucca recurvifolia.

[W. W.]

Shudes.—'Shudes' is a name used to designate the outer husk of certain grains. In this country it is applied more particularly to oats and rice. The 'shudes' consist practically of the outer glumes of the flower. Another name that is sometimes used for them is 'hulls', but this is more generally applied to the shells of peas and beans.

Shudes are not, properly speaking, a feeding material at all, for they are hard, indigestible, and frequently produce irritation in stock to which they are given. They consist largely of indigestible woody fibre, and have a considerable amount of silica; in the case of rice husk the quantity of this latter is very high, and the 'shudes' have a rough irritating feeling. Properly speaking, 'shudes' ought merely to be used for packing and similar purposes, or for treading down into manure, just as 'cavings' from threshing are employed. It is, however, unfortunately the case that 'shudes', both of oats and rice (and the latter in particular), are largely used for adulterating meals, different offals of wheat, &c., and for compounding in feeding cakes. The ease with which, when ground fine, they can be incorporated with such materials as barley meal, oat meal, wheat meal, rice meal, &c., and escape detection by the eye, renders their employment a profitable source for the dishonest trader. Even the shudes by themselves are sometimes ground very fine and are sold as 'pig meal', &c., or they are incorporated with meals as mentioned above. Not long since an exposé was made of a practice which had reached considerable dimensions, viz. that of selling under the name 'shudes' or 'shude meal' a material composed of sawdust and gypsum (sulphate of lime), the gypsum giving the appearance of flour being present.

The following are analyses of oat shudes and rice shudes:—

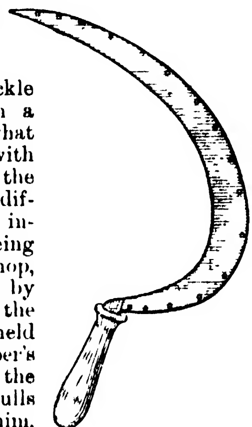
	Oat Shudes	Rice Shudes.
Moisture	9·23	9·70
Oil	0·49	1·16
[1] Nitrogenous matters ..	2·44	3·25
Digestible carbohydrates, &c.	50·73	32·44
Indigestible woody fibre ...	34·08	39·90
[2] Mineral matter (ash) ...	3·03	13·55
	100·00	100·00
[1] Containing nitrogen ..	0·39	0·52
[2] Including sand and silica	2·64	13·20

[J. A. V.]

Shying.—The sudden starting aside as if in fear, is known in horses as shying, and is a most objectionable habit and difficult to overcome. It has been attributed to defective sight, particularly to short sight and the inability to correctly focus objects at a distance. On the other hand, it is well known that many horses with defective vision caused by cataract and by opacities upon the cornea do not shy. Mr. Galvayne and other famous horse-masters attribute it to bad management at some period of the colt's education. Nearly all Russian ponies have the habit, and it is said that they acquire it in avoiding 'faults' in the ice over which they travel. If the habit originates in a nervous temperament it may be overcome to some extent by familiarizing the animal with the objects which most startle him, keeping an inverted wheelbarrow and a prone bicycle in the stable yard, and compelling him to stand while railway trucks are being shunted or motor vehicles started. If the shyer can be convinced that there is nothing harmful in the particular object he fears, he will

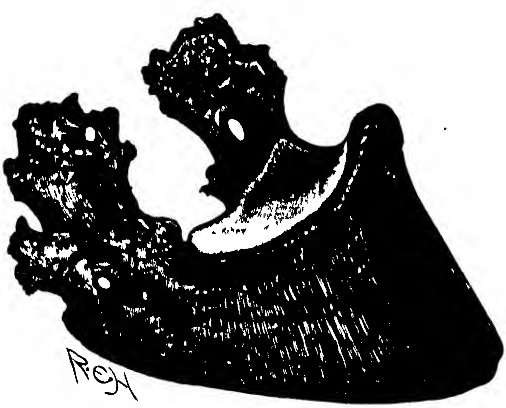
gradually cease to shy at it. When these measures fail, there is nothing to be done but arrange a more or less complete blindfold from one side of the bridle to the other. [H. L.]

Sickle. — The sickle as a tool for cutting corn has become almost extinct in recent years, though, before the reaping machine was commonly used, very large areas of grain were cut by it. The sickle is either made with a serrated or somewhat sawlike edge, or with a smooth edge; and the former is used in a different manner, as, instead of the cutting being done by a swinging chop, the corn is gripped by the left hand above the point of cutting, and held away from the reaper's body; whilst, holding the sickle in his right, he pulls it sharply towards him, practically sawing through the handful. The stubble is usually left 8 in. or so high. [W. J. M.]



Sickle

Sidebones. — The lateral cartilage which forms an extension of the pedal bone on each side is normally elastic and compressible under the finger, but specially liable to undergo a change in its structure, whereby the cartilage



Pedal Bones, showing ossification of lateral cartilages, constituting 'sidebones'

cells are filled up with mineral matter and it assumes the form of bone on the side of the foot, thus acquiring the name above given to it. Narrow and upright feet are perhaps more prone to it than others, and it is agreed by veterinarians that the defect is hereditary. Heavy horses are more subject to sidebone than nags. It may or may not be accompanied by lameness in the early stages, and it may be arrested before it has attained to any great size. The degree of ossification of the lateral cartilage, its presence or absence, has been the subject of dispute among experts, and many cases in the law courts. Pronounced cases are easily felt, and generally to be seen without special knowledge of anatomy. Much benefit is conferred by suitable shoeing. Blistering often has the effect of arresting further ossification, and is credited with causing a certain amount of absorption. Firing is resorted to in bad cases, and on the Continent sawing through the hoof and working the animal while reunion is taking place. The latter practice is discouraged in this country as being cruel and unjustifiable. [H. L.]

Silage. See ENSILAGE.

Silica and Silicates are compounds of silicic acid with metallic oxides. They form almost the whole of the mineral matter of the earth's crust, and even the remaining minerals are to a large extent derived from them. Silicon in fact plays in the mineral kingdom the same predominant part that carbon plays in the organic world; and it is remarkable that these two dominating constituents are chemically very closely allied.

Silica (SiO_2), the anhydride of silicic acid, occurs in the pure state, usually as a deposit from water, in quartz or rock crystal found in masses varying in weight from a fraction of an ounce to more than a hundredweight; also in a less pure state as sand. At ordinary temperatures it is comparatively inert, reacting only with hydrofluoric acid to form a volatile fluoride; but at very high temperatures it is chemically active, displaces most acids, and unites with most oxides to form silicates. This happened during the stage in the earth's history when the whole mass was molten.

The silicic acids do not occur in nature, but some of them have been prepared in the laboratory; like other weak acids they give rise to a number of complex and basic salts.

The Silicates.— An example of the simplest silicates is afforded by waterglass (K_2SiO_3); but such simple silicates rarely occur in the soil, usually two or more metals are present, aluminium almost invariably; iron, potassium, sodium, calcium, magnesium very frequently occur, and small quantities of manganese are common.

The silicates generally form isomorphous mixtures, so that no formula can be given to express exactly their composition; nor can tables of exact percentage compositions be drawn up, since these vary between the limits of isomorphic replacement.

The following are some of the important silicates in the soil:—

Orthoclase or potash felspar ...	$AlKSi_3O_8$.
Albite	$AlNaSi_3O_8$.
Anorthite	$Al_2Ca(Si_3O_8)_2$.
Kaolinite	$Al_2Si_2H_4O_9$.
Muscovite (mica) ...	$AlSiO_4\left(\frac{Al}{Fe}\right)$.
Chlorite	$MgSiO_4\left(\frac{Al}{Fe}\right)_2$.
Hornblende (see the art.)	
Augite	$MgOSiO_2$, or $\left\{\begin{matrix}MgO\\CaO\\FeO\end{matrix}\right\}SiO_2$.
Leucite	$KAlSi_2O_6$.

In all cases there is likely to be some isomorphic replacement.

The first three decompose and give rise to the clays; orthoclase forming kaolin, which contains kaolinite. Hornblende and augite are often black from the presence of magnetic iron oxide, and as such form the black constituent of many rocks; they readily weather. Mica, on the other hand, does not. The Zeolites (*e.g.* Natrolite) are a class of compounds derived from the original rock silicates by some chemical changes occurring in the cavities of basalt, lava, and less frequently, granite and gneiss; they are hydrated silicates of alumina with lime, soda, potash, and occasionally baryta. Many of them froth up when heated before the blowpipe, hence their name (zeolite = 'boiling stone'). They are distinctly reactive, and have been supposed to play an important part in the soil (§ 19, SOIL).

[E. J. R.]

Silk is the fibre produced by a 'worm' or caterpillar, in order to form a protecting case or cocoon, in which it may live in safety as a chrysalis, until the time comes for it to emerge as the winged insect or moth. The moth lays eggs, which, after a certain period of hibernation, spontaneously hatch and yield worms. These are fed on certain plants until in their turn they attain maturity and spin their cocoons. After a second hibernation as chrysalids, the final stage, of the perfect or winged insect, is once more attained, when each cocoon gives forth a male or female moth. From egg to moth is thus the life-cycle or generation, and when this is accomplished only once a year, the insect is termed *univoltine*. But certain breeds (or perhaps rather climatic races) are known to be *bivoltine*, that is to say have two generations a year; others are *trivoltine*, *quadrivoltine*, or even *multivoltine* (have as many as eight or nine broods a year). But the nature and quality of the silk varies according to the species or race of silkworm reared and the kind of food plant on which fed. By far the most important silkworms are those that live on the mulberry, and, because these have been for the longest time domesticated, they are often classed as the *Domesticated Silkworms*, all the others being thrown together into a second group, sometimes designated the *Wild Silkworms*. The mulberry-feeding silkworms, however, belong to a different tribe—the Bombycidæ—from the non-mulberry-feeding species—the Saturniidæ. Moreover, the silk obtained from them is much superior, and also so very different from that of the wild silks, as to have caused many writers to speak of the mulberry as 'true silk' and to place all the others either as 'wild silks' or as 'tasar (tusser, tussore, &c.) silks'. But within recent years a new complication has arisen. The cocoons, after a certain treatment which softens them, are reeled; that is to say, the threads (*bave*) worked into the walls of the cocoons are drawn out, and two or more such original filaments are thrown together and twisted around each other to form the yarn employed by the silk weavers. A small portion of each cocoon cannot, however, be reeled, and, until quite recently, that portion was treated as waste. It is now carded and then spun, thus forming yarn quite different from, and inferior to, that of reeled silk, but still very valuable. Now, since many of the wild silks cannot be reeled at all, or reeled very imperfectly, they are largely carded and spun, and either used by themselves as special silks, or are mixed with carded mulberry silk and worked up in the form of various grades of spun silks, so that in modern commerce we have now two important kinds of silk—reeled and spun.

The mulberry-feeding insect is *Bombyx mori*. It was perhaps originally indigenous to the warm temperate regions of northern China and the mountains to the south, until the confines of Burma and India were reached. To-day the worm has been taken to every part of the globe where it has been found possible to grow the mulberry plant. But just as there are several distinct species, and under each of these many different races of the plant, so there are numerous forms of this silkworm, some of which have been evolved within the countries of their production. Of the countries that now produce silk, mention may be made of the following: *Europe*—Italy (Lombardy), France (Central and South), Spain, Portugal, Russia; *Asia Minor, &c.*—Turkey, Algeria, Egypt, Syria, Armenia; *Asia*—Central Asia, Persia, Afghanistan, Kashmir, India, China, Japan, Corea, Siam, Burma, &c.; *America*, and *Australia*.

The mulberry silkworm everywhere thrives best and gives the finest silk where the climate is temperate, so that the insect may be only univoltine, or at most bivoltine, and its food plant one or other of the races of the White Mulberry (*Morus alba*). Under skilled treatment, both of the food plant and the insect itself, immense improvements have been effected, especially in Europe and Japan, so that it is commonly said, both of China and India, that they have fallen below the modern level of quality. But this is largely due to the fact that the climate of the areas of greater production in these countries is almost tropic, thus causing the insect to become multivoltine, and necessitating the use of other and less favourable species of mulberry, such as *M. indica*. Moreover, the heat of these regions engenders a spirit of indifference if not of apathy on the part of the cultivators—a frame of mind fatal to sericulture. In perhaps no other industry is cleanliness, regularity, and method more essential than in silk-rearing. In the most highly favoured silk growing countries the mulberry is grown as a tree (the standard system). This is the practice in Europe and in northern India (Kashmir, the Punjab, &c.), but in more tropical tracts the bush system prevails, as for example in Bengal. Not only is the insect immediately influenced by the race or stock of the food plant given it, but by the method of cultivation pursued. Thus many insects will not eat leaf produced from the bush cultivation, even if the plant used be the same, while others, such as the *chhotapalu* of Bengal, will only thrive on bush-produced leaf. The mulberry can be grown on any kind of high well-drained soils, but more successfully on loams than stiff clays.

From 1865 to 1870 Pasteur devoted himself

to the study of the diseases of the silkworm, and the remedial measures which he recommended have since been not only widely adopted in Europe, but throughout the silk-rearing regions of the world. These consist in the selection, under the microscope, of eggs free from disease, and the rejection of all eggs laid by diseased moths. It is most important that the hatching should not take place till the mulberries have put forth their spring flush of leaf —this is the foremost of all considerations. Immediately the eggs are hatched the worms are just a little over ⅛ in. in length. They are at once given mulberry leaves cut into fragments ⅛ in. in size, and spread, for that purpose, on shallow wickerwork trays, arranged on shelves within a well-ventilated breeding shed. The worms rapidly devour the leaf and increase in size, the skin of the rapacious creature being from time to time renewed. The greatest care must be bestowed in removing the waste materials, with the supply of each fresh batch of leaf, the worms being allowed to crawl from the old to the new supply. Uniformity of climate and liberal ventilation, combined with thorough cleanliness, are the essentials of success. On the worms discontinuing to eat, they are placed in large trays, partitioned off into numerous cells, each sufficiently large to allow the caterpillar to spin undisturbed and to change into the chrysalis. Cocoons with a hard, firm shell and of large size are most valued, since they contain a greater amount and higher percentage of silk, capable of being reeled. Soft, thin, and small cocoons are inferior in value. If intended to be reeled, the cocoons are heated in an oven, or are steamed until the contained chrysalids are killed; then they are baled and consigned to the filature, and finally the silk reeled from them is taken to the mill, to be worked up into silk goods.

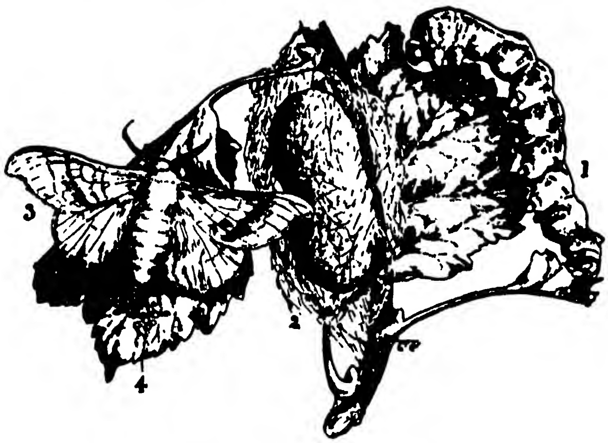
The 'Wild Silks' are both numerous and diversified, so that to do them justice a little volume would have to be written, and the reader is therefore referred to technical works, of which many exist. Speaking generally, they may be said to be collectively much more tropical in their habitats than the mulberry insect, and less restricted in their food plants. The one most often mentioned is the Indian Tasar (*Antheræa paphia*), a denizen of the upland forests of that country, and mainly in regions unsuited to Europeans. The insect is an intractable one that has resented all efforts at domestication, lives on lofty trees, and has but one advantage, viz. the cocoons are large, are suspended from the twigs, and can thus be readily seen. Collection is, however, expensive, and comparatively little progress has been made with this insect. All this is changed with the Chinese Tasar (*A. pernyi*); it is a native of warm-temperate tracts, feeds on the oak leaves, has been semi-domesticated for centuries, and gives two crops a year. But in modern commerce any silk fabric of a golden-yellow colour (nowadays made very often of spun waste silk) is in European retail trade described as tasar. The 'Muga Silk' of Assam is well known, and very different from tasar, though in European commerce the two are hardly distinguished. The insect that produces it is *Antheræa assamica*. It occurs throughout the eastern side of India, and is fed mainly on the leaves of a laurel (*Litsæa polyantha*). It exists in a state of semi-domestication, the worms being placed on the trees to feed and then removed indoors to spin their cocoons. There are generally five generations a year, but, of these, two are regarded as the chief and the most valued. The 'Eri Silkworm' (*Attacus ricini*) has many features of great merit, so that it may be said, of all the wild silks, to be the one deserving of the greatest attention in the future. It is fed on the leaves of the castor-oil plant, which could be systematically produced for it; is naturally multivoltine, and can be reared entirely within doors, so that it may be spoken of as completely domesticated. It is fairly largely reared in India to-day, but is capable of indefinite extension as an auxiliary in tropical agriculture. Other wild insects exist in Madagascar, Africa, Japan, Java, &c.; but the above particulars are sufficiently indicative of the present position and future prospects of the wild-silk industry of the world. Their future turns on cheap production and an extended demand for carded silks. [G. W.]

Silkworms.—The common silkworm is the caterpillar of a moth called *Bombyx mori*. This insect has been cultivated for a great many years, and is probably the one first used in China in very remote periods. As far back as 2640 B.C. the Empress Se-ling was known to have largely encouraged the rearing of the silkworm and the reeling of silk. The Chinese guarded this worm most zealously, and it was not until 300 A.D that silk was made in Japan. Soon after, the silkworm spread to India. In 550 A.D. two Persian monks, encouraged by the Emperor Justinian, went to China and brought back large quantities of silkworm eggs and mulberry seeds hidden in bamboo staves. From this stock, manufactures were set up in Corinth, Athens, and Thebes, and later spread over Italy, France, and Spain. The stock which the Persian monks introduced supplied the worms which supplied the Western Hemisphere for 1200 years, but in the last century the introduction of new stock became necessary.

The greyish silkmoth *Bombyx mori* and its allies and races are all incapable of any proper flight. Several so-called species, most apparently only local races, of *mori* are cultivated, such as the Boropooloo of Bengal (*Bombyx textor*), which has one generation per annum; the *Bombyx sinensis*, the Chinese Monthly Worm, which has several generations; the Madrasi Worm of Bengal (*B. Crœsus*), the Desi Worm of Bengal (*B. fortunatus*), and the Burmese Worm (*B. arracanensis*).

These silkworms feed upon the foliage of mulberry and require constant care. The grey worm lives for six weeks, and moults its skin four times. Before they are going to spin, they are either separated or bunches of fine twigs are put with them, and the so-called worms 'head' or 'mount' upwards and spin the cocoons amongst the twigs. The cocoon takes about three days to form, and is composed of an inner compact

portion, the 'pod', and an outer loose mass, the 'floss'; the silk is woven in a figure-of-eight. A cocoon weighs from 15 to 50 gr. Two threads leave the mouth, but are soon united. The length of silk in a cocoon is from 4000 yd. and upwards. Of this, only some 900 can be reeled. The pupal stage lasts about three weeks. The



Common Silkworm (*Bombyx mori*)

1, Caterpillar. 2, Cocoon. 3, Female moth. 4, Eggs.

females lay about 500 eggs. They winter in the egg stage.

The silk fibre of Bombyx is roundish in section, and varies from $\frac{1}{700}$ to $\frac{1}{1000}$ of an inch in thickness; it consists of a core of fibroin covered by silk albumen or sericin, a waxy colouring matter. The large silk glands manufacture the semi-liquid fibroin, and the action of the oxygen in the air transforms the external pellicle into a more soluble form—sericin. One ounce of ova (*graine*) = 400,000 ova, and the young from these consume in their first stage 6 lb. of mulberry leaves, in their last stage 1098 lb. These worms should yield 80 to 100 lb. of cocoons, of which 85 per cent is composed of pupæ.

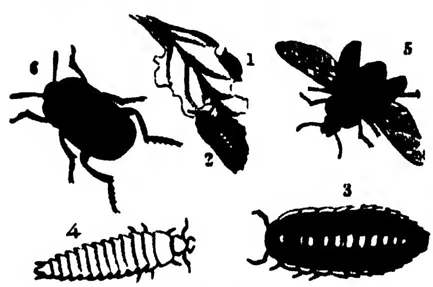
Wild silkworms are now largely used, belonging to the genera Attacus and Antheræa. The so-called Eri Silkworm or Arrinda (*Attacus ricini*), which feeds on the castor-oil plant, is important in Assam and Bengal, but the silk is difficult to reel. The Ailanthus Silkworm (*Attacus cynthia*), a native of China and India, is also used, and spins a silk of a drab colour. This has been used in France. In Japan the Oak-feeding Silkworm (*Antheræa yama-mai*) is in favour. Its cocoon is alone surpassed by *mori*; it is larger, and the silk is of a greenish-gold, the floss being coarse. The moth is 6 to 7 in. across the wings. It was introduced into France in 1862 under great difficulties, the exportation of eggs then being punishable with death. The worm is a beautiful green with yellow sides, and silvery spots and tufts of spines and hairs. The well-known Assam silks are made by the Assam Worm or Muga (*Antheræa assamensis*) peculiar to the district. The Chinese Tussur (or Tasar) Silkworm (*Antheræa pernyi*) is an oak feeder native to Mongolia. It yields some of the Tussur silk that is imported into Europe. It forms two cocoons a year of dull-yellowish-white strong silk easily wound. The famous Indian Tussur silk is the product of another worm, *Antheræa mylitta*, found nearly all over India. The worm feeds on a great variety of Indian plants.

The old domesticated worm suffers from two diseases—one, 'pebrine', nearly stamped the worm out in France in 1876. The discovery of its cause and prevention by Pasteur is now a matter of history. Another disease, 'muscadine', is due to a fungus, *Botrytis bassiana*.

Silk farming has never been seriously taken up in Britain, but there is no reason why it should not pay. [F. V. T.]

Silpha atra.—This beetle is black and shiny, very like the next beetle, but has no ridges on the wing cases. Its economy is very similar.

Silpha opaca (Linn.), the Beet Carrion Beetle, frequently found in cornfields, is supposed to injure the wheat crops. It inhabits, however, dead carcasses in the spring, summer, and autumn; hibernating in winter in moss at the roots of trees, &c. The economy of the larvæ is singular; for, instead of feeding upon putrid animals, like their congeners, they live upon the healthy beet leaves; and where they attacked the young plants, entire crops have been swept off by them. In France and Ireland the larvæ have committed extensive ravages; while frequent reports of the damage done to wurzel have been recorded in this country.



Beet Carrion Beetle (*Silpha opaca*)

1 and 2, Larvæ. 3, Larva (magnified). 4, Larva. 5, Female beetle. 6, Male beetle

The larvæ first appear the third week in May, and are matured about midsummer. They are black and shining; the head is large and bent down, and there are two antennæ composed of three segments; they resemble wood-lice (see figs. 3 and 4), being formed of about thirteen segments, with two-jointed spines at the tail, but they have only six little legs. Figs. 1 and 2 show the young and full-fed larvæ devouring a beet

leaf; fig. 3 shows one magnified, as well as fig. 4, which is more attenuated, and supposed to be the male. They bury themselves to change to pupæ. The beetles are black and punctured, but clothed at first with short tawny hairs, giving them a surface like satin. Fig. 5 is a female flying; 6, a male walking, a little magnified. As the beetles breed in manure, it is important that on land subject to this attack it should be ploughed in at once. [J. C.] [F. V. T.]

Silpha quadripunctata (the Spotted Silpha).—This species can at once be told by having the margins of the thorax and the elytra of a dull-ochre-yellow, the elytra having each two black spots. It is found in summer on oaks, where it mainly feeds on caterpillars. [F. V. T.]

Silphidæ (Carrion, Burying, and Beet Beetles), a family of beetles containing two well-known genera—Necrophorus (Burying Beetles) and Silpha (Carrion and Beet Beetles). The former, of dull-red-and-black, feed upon dead animal matter. The latter are smaller and rounder, seldom more than ½ in. long, generally black in colour and flattened. The Silpha are omnivorous, feeding on dung, carrion, and insects, as well as vegetation. Two species are harmful to crops. The larvæ are active and six-legged, and with their segments notched or with sharped edges. See preceding articles. [F. V. T.]

Silt.—Silt, in the broad geological acceptation of the term, is applied to any fine-grained products of rock weathering that have been deposited from water. In the science of soil-physics the term has been used for the particles which constitute the 'fine earth' of a soil. The term is also used by many soil-analysts to denote the grade of soil-grains intermediate in size between fine sand and clay. The dimensions of the silt grade are variously placed at diameters of ·25–·0015 mm., ·05–·005 mm., ·04–·002 mm., or ·01–·005 mm., &c. Silt in this restricted sense has the function, in the soil, of a coarser clay, inasmuch as it presents a comparatively large surface to serve as a feeding ground for plants and for the retention of soil-moisture. It differs, however, from 'clay' in favouring a higher rate of capillary water movement, and in contributing less stiffness and tenacity to a soil. [T. H.]

Silurian System.—Under this head will be described the strata and soils that belong in reality to two systems. These are commonly separated as *Ordovician* (or *Lower Silurian*) and Silurian proper (or *Upper Silurian*) respectively. The Upper Silurian is also styled Gotlandian by those who wish to retain the term Silurian, as established by Murchison in 1835, as a convenient one to cover both the systems, especially where their limits have not been adequately worked out. The broad use of 'Silurian' prevails in many parts of the Continent and in Ireland.

The strata included under this general name are as follows:—

Upper Silurian (Gotlandian; Silurian as often restricted).	3. Ludlow Series. 2. Wenlock Series. 1. Llandovery Series.
Lower Silurian (Ordovician).	3. Bala and Caradoc Series. 2. Llandilo Series. 1. Arenig Series.

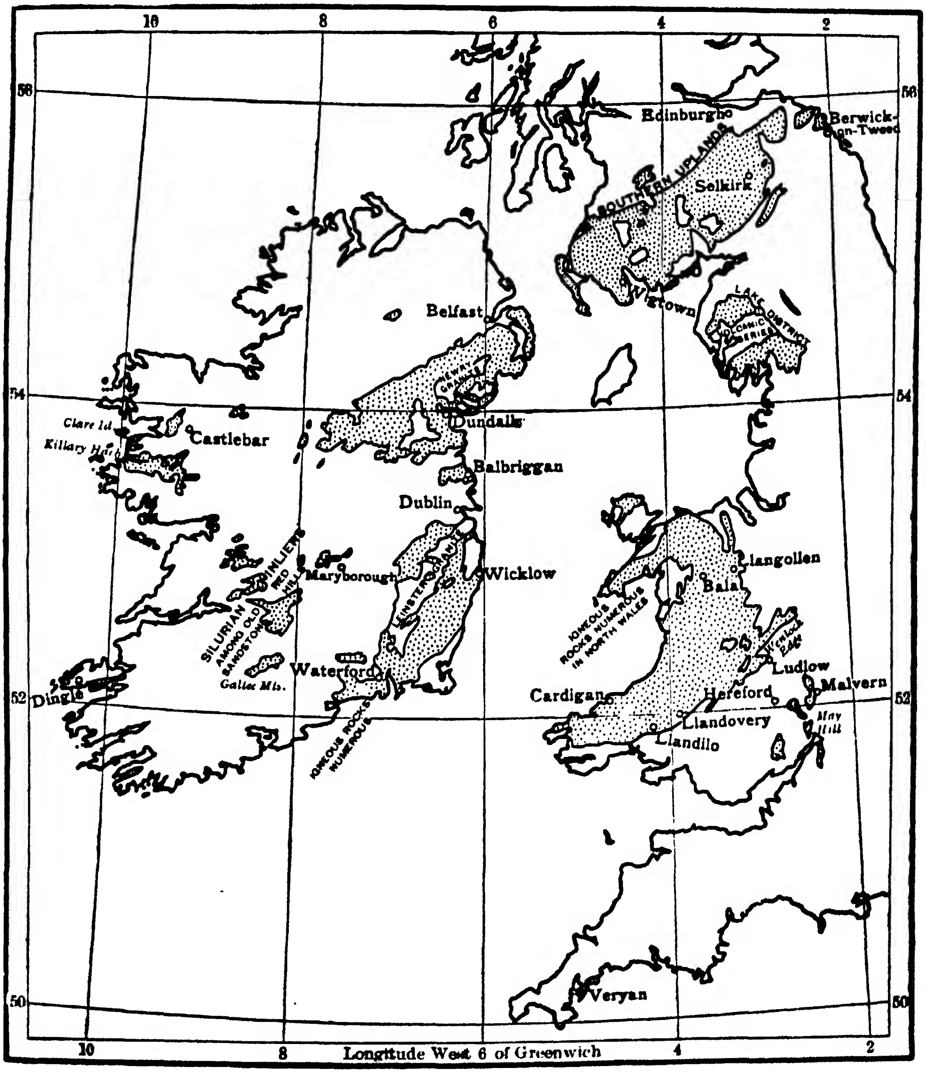
Consisting of old shales, often converted into slates, and well-cemented sandstones, passing even into quartzites, the Silurian beds give rise to hummocky land, even where not elevated into the region of crags and precipices. There is a remarkable deficiency of limestone in the Lower Silurian system.

The **Lower Silurian** or **Ordovician** System is best studied in North Wales. The ARENIG SERIES includes numerous flinty rocks representing ancient lavas. The volcanic activity that began in this area in late Cambrian times gave rise in the Arenig epoch to a number of intrusive and extruded masses, among which is the columnar 'felsite' that forms the great craggy wall of Cader Idris. The volcanic ashes sometimes produce milder features; but many have been baked into flinty types by later intrusions of igneous rock. The Stiper Stones of Western Shropshire are a ridge of Arenig quartzite. The LLANDILO or LLANDEILO SERIES occupies a considerable area of the hilly ground in south-central Wales, and consists of shales and sandy flagstones, with some calcareous matter. In North Wales these beds occur above the volcanic rocks of the Arenig Series on the Merionethshire anticlinal, appearing thus high on the back of Cader Idris and at Tremadoc. The BALA SERIES corresponds in age with the CARADOC SERIES of Murchison, established on the Shropshire border. A limestone band is a conspicuous feature near Bala. Otherwise, slates and sandstones prevail; but among these are intercalated enormous masses of igneous rock, mostly tuffs and lavas of a highly siliceous nature. These have weathered out, largely under the influence of frost in glacial times, to form the precipitous crags of the Snowdon group and the associated hills. Farming can here be carried on only in the valley-floors, and the ground is much cumbered by angular blocks that have fallen from the heights. Nodular phosphorite, forming a bed at times 18 in. thick, occurs in the upper part of the Bala Series in the Berwyn Hills, and has been worked commercially. This fact bears out the conclusions come to in regard to still earlier strata (see art. CAMBRIAN), and shows that Silurian soils need not suffer from a paucity of calcium phosphate. In the Lake District, the *Skiddaw Slates* pass down into the Cambrian, but are mainly of Arenig age. The most mountainous and barren ground is formed by a mass of highly siliceous tuffs and lavas, the BORROWDALE SERIES, erupted in Llandilo times. Most of the gentler ground is left for sheep, and much is occupied by private parks. The CONISTON LIMESTONE SERIES is of Bala age, and includes the *Ashgill Shales*. This series lies mostly on the south of the mountain region.

Representatives of the Lower Silurian system occur as a broad band on the north-west edge of the southern uplands of Scotland, and as inliers throughout that hilly area. In Ireland, Lower Silurian shales and slates occur as inliers in the broad area from Belfast Lough to Longford. Similar rocks, often altered by the granite into mica schists, flank both sides of the Leinster Chain. The rivers from the central axis

cut ravines when they enter these beds, and a broken wooded country results, descending into a drift-covered hummocky lowland in the east of Wicklow. Numerous igneous rocks, diorites and 'felsites', provide prominent features, and these are especially abundant in the south of Co. Waterford. Bala Limestone occurs on the Chair of Kildare and at Portrane in Co. Dublin. In the Killary Harbour area of South Mayo and North Galway, great masses of slate, sandstone, and conglomerate rest unconformably on the Connemara metamorphic series, and are in part of Lower and in part of Upper Silurian age. Arenig, Llandilo, and Bala rocks are recognized in this mountainous region.

The **Upper Silurian** (or **Silurian** system as re-



stricted) is typically developed in south Shropshire, where the Llandovery beds rest unconformably on Caradoc sandstone. The Llandovery Series is formed in Wales and England of sandstones and grits, and the upper beds, appearing as an inlier at May Hill, north-east of the Forest of Dean, have been marked off as the *May Hill Sandstone*. The Wenlock Series is finely seen on the scarped face of Wenlock Edge in Shropshire, where the *Wenlock Shales* below, producing gentler slopes and stiff clayey ground, are capped by the mass of the *Wenlock Limestone*. The Ludlow Series comes in above, containing some limestone, but consisting mainly of flaggy sandstones, and shales which produce wet muddy ground. Its highest beds form the micaceous flaggy *Downton Sandstone*.

In North Wales, the Upper Silurian strata are on the whole sandy, and form high moorland country in the Berwyn Hills. The *Ta-*

rannon Shales at the base are a thick series, often slaty, which extend far into South Wales, where they overlie Upper Llandovery beds. The *Denbighshire Grits* represent the Wenlock Series, and can be traced from Conway to Radnorshire. They are sometimes more argillaceous at the base.

In the Lake District, the Upper Silurian system is represented by slates and sandstones producing hilly country in the south of the area. The southern uplands of Scotland, a picturesque region largely devoted to sheep-farming, consist mainly of Upper Silurian rocks. Some cultivation is carried on in the long alluvial valleys, but much of the country, even at a low level, is pure moorland, and the few roads that traverse it have the character of mountain passes. Granite bosses have penetrated these Silurian beds, and add important features to the southern landscapes. A large part is played by the shales and grits of the BIRKHILL SERIES, which are of Llandovery age. Tarannon, Wenlock, and Ludlow rocks succeed one another in this area.

In Ireland, the areas of Upper Silurian rock are much more extensive than was formerly supposed. In the region from Longford to the north of Co. Down, representatives of the Birkhill Series occur, revealing inliers of Lower Silurian rocks beneath them. The country is hummocky and irregular, and the ground, formed of slates and hard sandstones, has been difficult to cultivate. The Newry granite forms a ridge in the centre, and the Cainozoic granite of the Mourne Mountains also breaks through this area. In the Killary Harbour area, Upper Silurian rocks appear in a mountainous country, which is contrasted with the Carboniferous lowland to the east. Several of the inliers among the Old Red Sandstone domes of the centre and south of Ireland reveal shales and sandstones of Llandovery age. These weather down more easily than the surrounding Old Red Sandstone, and form broad upland basins, occupied as farm lands, shut in by more forbidding hills.

[G. A. J. C.]

SILURIAN SOILS.—A not inconsiderable portion of the Silurian area of the British Isles is an unenclosed waste, or at best only suitable for rough pasturage, while, on the other hand, much of the land on this formation has been successfully cultivated, and in fact includes some of the best-farmed districts in the kingdom.

The southern uplands of Scotland, which are composed of Upper and Lower Silurian rocks, but mainly of the former, do not furnish soils of very great fertility. At the greater elevations they are cold and poor, but at lower levels, although abounding in coarse, stony material, land of a better description may be found.

In Wales the Silurian land is on the whole of an inferior type; while the same may be said of the Cumberland district; but the Skiddaw Slates produce a deep soil which bears a better vegetation than is found on the soils of the other Arenig rocks.

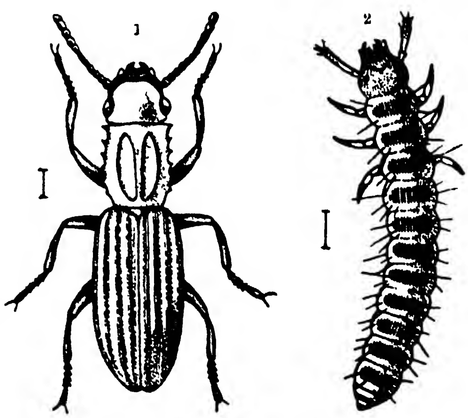
The Llandilo Series, as developed in Shropshire and round Caermarthen, forms a light free-working loam well adapted for barley, turnips, and potatoes, while the soils of the Caradoc sandstones of Shropshire are of an inferior type, except where lime is present naturally or has been applied to the soil under cultivation (Journ. R.A.S.E., 1858, p. 1). The non-calcareous Caradoc lands are frequently covered with heaths.

Phosphatic material occurs in abundance in the limestones of Bala age, so that where these rocks outcrop, their influence on the fertility of a district is at once manifest; for example, the narrow rich belt of land in Westmorland extending from Windermere to Shap Fell coincides with the outcrop of the Coniston limestone (M'Connell, Agr. Geol., p. 171).

Two of the best-farmed counties of Ireland, viz. Down and Wexford, are mainly Silurian areas. The soil of the former county is a stony loam of only moderate fertility, but it is farmed so well that it produces excellent crops of oats, turnips, potatoes, &c. The Wexford soils, having been enriched by accessions of boulder clay and other superficial deposits, are of average natural fertility, and furnish in places well-known barley soils. The Silurian rocks of Monaghan and Cavan are very thickly covered with drift derived from the local fine-grained sandstones and shales; the soils on this drift are strong retentive loams of rather poor quality.

Except where the rocks include limestone beds, the Upper Silurian strata, as a rule, form cold tenacious clays. Some sandy beds at the top of the Ludlow Series form lighter and more open soils, which become fertile loams when they possess sufficient lime. In Shropshire the Wenlock Limestone makes very useful tillage land (Journ. R.A.S.E., 1858, p. 2). [T. H.]

Silvanus surinamensis (Linn.) is a minute beetle which inhabits granaries, feeding



Silvanus surinamensis

1, Beetle 2, Larva.

(Lines show natural sizes.)

upon the grain. It is of frequent occurrence in stores, where it feeds upon groceries, meal, and almost all edibles. The larva is a six-legged, whitish worm, upwards of a line long, with a large head and two longish antennæ. The pupa is smaller. The beetle is $1\frac{1}{4}$ line long, very flat and narrow, of a rusty-brown colour,

thickly and coarsely punctured, and sparingly clothed with short, yellow, depressed hairs; the head is large, subtrigonate; the antennæ are stout, straight, and clubbed; eyes small and black; thorax oval, with three ridges down the back; elytra long and elliptical, with eight elevated lines, having alternate double rows of punctures and little shining bristles; beneath them are two ample wings; legs short and stout; feet five-jointed.

The female lays her eggs amongst meal, &c., and in the same place pupation takes place; the pupa may lie in a cocoon of meal or may be naked. In this country, reproduction ceases in winter, the beetles hibernating in stores and granaries. The whole life-cycle varies from five to ten weeks in Britain, but in America it may pass through them in twenty-four days. Infested substances are best treated by being baked or heated through, or they may be subjected to the fumes of bisulphide of carbon with the exception of flour. [J. C.] [F. V. T.]

Silver Fir (Abies) is a genus of the Abietineæ tribe of the nat. ord. Coniferæ, to which also belong Pine, Spruce, Hemlock, Douglas Fir, Larch, and Cedar. Like all of these except the Pine, it has thin broad cone-scales, becoming thinner at the edges. It is an evergreen tree, with single leaves ranged spirally around the twigs and persistent for several years, and with cones ripening in the year of flowering. The Douglas Fir is the genus having the closest affinity and resemblance to the Silver Fir. In both the leaves are two-sided and have two resin-ducts along the lower surface; but in Silver Fir the leaves are sessile and indented at the tip (except in *A. Pinsapo*), and the cones are larger and erect, and shed the scales along with the seed in autumn; whereas in Douglas Fir the leaves are petiolated and pointed, and the cones are smaller, pendulous, and with persistent scales, while the three-pointed flower-bracts are longer than in the Silver Fir. And after the pole-stage of growth has been passed, the bark of the Silver Fir remains whitish and little fissured, whereas that of Douglas Fir becomes dark and much fissured, though both exhibit pustules of resin before fissuring takes place. Over thirty species of Silver Fir are known, of which only four are indigenous to Europe—the Common Silver Fir (*A. pectinata*), the Crimean (*A. Nordmanniana*), the Grecian (*A. cephalonica*), and the Spanish (*A. Pinsapo*). Numerous other species have been introduced into Britain for ornament, of which the chief are the *A. grandis*, *A. concolor*, and *A. nobilis* (with incurved silvery foliage) from California, and *A. Pindrow* and *A. Webbiana* from the Himalayas. But the Common Silver Fir is the only species likely to be grown extensively as a woodland crop in Britain. Introduced as an ornamental tree in 1603, it attains over 120 ft. in height and over 17 ft. in girth when growing isolated; and these dimensions seem likely to be exceeded by the Great Silver Fir (*A. grandis*) introduced in 1831, with longer and less pectinate foliage, but softer wood. The Common Silver Fir is the largest of European trees, and produces the largest crop per acre. As it has a heart-shaped root-system, it needs a fairly deep soil, and thrives best on deep sandy or fresh stiffish loam. It does not do well on wet land. Its lustrous whitish timber is soft and light, and much resembles Spruce, along with which it is often sold as 'White Deal' from Rotterdam, or else specially as 'White Pine' or 'Swiss Pine'. Though whiter and softer than Spruce, it is slightly heavier (sp. gr. 0·97 green, 0·47 seasoned); but they fetch about the same price, and are equally clean in the stem when grown in close canopy, as they both endure side-shade. It is also less resinous, though producing 'Strassburg turpentine'. In Britain it grows well up to about 70 years of age, then falls off in growth, and at about 90 to 100 years becomes overmature and subject to insect attacks (Sirex, Chermes), the lice especially being then apt to infest younger trees, and often to kill them in large numbers. Grown closely it produces seed from 60 to 70 years of age onwards, good seed years occurring at intervals of 3 to 8 years. The seedlings need protection from early frosts, and also against drought in a dry summer. In nurseries this has to be provided artificially (by branches, screens, &c.); but in the Central European woods natural protection is given by regenerating it in groups under the parent trees, which are gradually removed when the saplings are over 5 to 6 ft. high and above frost level. But as the young trees stand shade well on good soil, the removal of the parent trees is often extended over 20 to 40 years, in order to gain the advantage of the large increment that takes place in the free exposure to light and sunshine. In the mountain forests of Central Europe Silver Fir is thus worked with a rotation of 150 to 180 years, with natural regeneration extending to about 30 years or more. In Britain, however, a rotation of about 70 years seems likely to offer the largest profit. It answers better than Spruce for underplanting thin crops of Oak or Larch on good soil, as it endures more shade and its leaves persist longer (5 to 7 years). The seedlings are of slow growth for the first 4 or 5 years, and planting with 2-year-3 transplants is therefore better than using 2-year-2 plants. Afterwards, however, they grow rapidly, and if mixed with Spruce will usually catch this up and shoot ahead between 15 and 20 years of age. As a woodland crop it is best planted pure in groups on good deep soil in a fairly sheltered position, in parts having a soil perhaps too stiff for Douglas Fir (which is the only other tree likely to furnish a larger and more valuable crop per acre). If young plantations are made, the plants should be pitted at 4 by 4 ft., and interplanted here and there with quick-growing nurses to protect them (Robinia, Larch, Pine, and Birch), which should be cut out when they have sufficiently fulfilled this task, even if not yet of fairly marketable size. Silver Fir suffers less than Scots Pine, Spruce, or Larch from insect attacks and fungous diseases. Among insects the Bark Louse (*Chermes piceæ*), the Pine Weevil (*Hylobius abietis*), and the large yellow Wood Wasp (*Sirex gigas*) are the chief pests; while among fungi, *Agaricus melleus* and *Fomes anno-*

sus attack the roots, *Trametes pini* and *Pestalozzia Hartigii*, *Phoma pithya*, and *Æcidium elatinum* the stem and branches, and *Trichosphærica parasitica* and *Lophodermium nervisequium* the leaves. It is a tree that will probably well repay planting on a much larger scale than has yet been done in Britain; and especially in the warmer parts. [J. N.]

Silver Fir.—Parasitic Fungi. — LEAF CAST.—Premature loss of leaves may be a symptom of frost or smoke damage, but in some cases parasitic fungi play a part. In crowded nurseries and plantations one often sees numerous brown needles hanging loosely from the twigs, attached merely by a few fungus filaments. The distinguishing of the particular fungus at work requires some skill, but the action in causing loss of leaves is a drain on the tree. No successful treatment is known except to thin out diseased trees and to plant hardwoods.

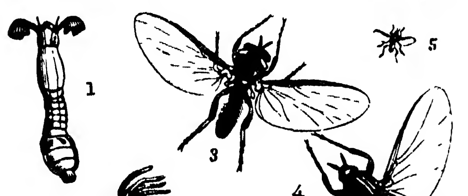
WITCHES' BROOMS.—These conspicuous bunches of erect twigs are frequently seen on Silver Fir. The needles are small and last only one year; they also become coated with yellow æcidiospores of the rust-fungus *Æcidium elatinum* almost as soon as they unfold in spring. These brooms should be cut off if sound timber is desired, because the branch becomes permeated with fungus filaments and a cankered resinous swelling results. This fungus has also a teleutospore stage, which lives on Chickweeds and Stitchworts occurring in the undergrowth round plantations.

STEM ROT.—Several fungi belonging to the Polypore group effect an entrance through wounds in stems and roots, and cause decay (see TIMBER-DESTROYING FUNGI). [W. G. S.]

Silver Moth. See PLUSIA GAMMA.

Silver Weed. See art. POTENTILLA.

Simuliidæ, a family of flies popularly called Sandflies, Brulots, Turkey and Chicken gnats.



Simuliidæ—Sandflies

1, Larva; 2, pupa—both magnified. 3, Male; 4, female—both magnified. 5, Insect, natural size.

The females torment cattle, birds, and man by entering the ears and nostrils and alighting on the eyelids; they then bite and suck those parts, creating an insufferable irritation. They swarm in damp places in spring, summer, and autumn. In Hungary, on the banks of the Danube, a species named *Simulium columbacschense* is so great a pest that hundreds of horses and cattle are suffocated by the flies getting into their windpipe. The Sandflies are equally annoying in Africa and South America. In North America they also swarm, and do a deal of harm to stock. In this country, although they are present, they are not very annoying. The eggs are laid upon water-plants and rocks, and the curious larvæ and pupæ (figs. 1 and 2, magnified) live there. The larvæ prefer running water, taking up their abode, often in dense masses, near cascades and rapids. The pupa (2) lies in a cocoon of various shapes with the head and filaments protruding. The following are the most troublesome species in this country, and they are all one line long:—

S. reptans (Linn.).—The male is black; head whitish in front; thorax with gilded tomentum, sides white, and an interrupted white band in front. Legs dark; wings limpid. Female black with ashy tomentum; sides of thorax silvery, and a white spot on each side in front.

S. maculatum (Meig.).—Deep-black; thorax with short hairs, a cinereous tomentum over thorax and part of abdomen. Head black, white beneath. Legs entirely brown. Halteres dark in the male, yellow in the female.

S. latipes (Meig.) is black, clothed with golden hairs; the legs are reddish; the fore shanks white. Two others occur in Britain (*S. ornatum* and *S. nanum*). [J. C.] [F. V. T.]

Sinclair, George (1786-1834), agricultural writer, was born at Mellerstain, in Berwickshire. He came from a long line of gardeners, many of whom were noted men in their day. When comparatively young he was appointed gardener to the Duke of Bedford at Woburn Abbey, and it was here that the great work of his life was originated and carried out. By instruction from the Duke, and under the guidance of that master of science, Sir Humphry Davy, Sinclair conducted an extensive series of experiments, the results of which were published in a costly folio entitled Hortus Gramineus Woburnensis, or an Account of the results of experiments in the Produce and Nutritive Qualities of different Grasses and other Plants used as the Food of the more valuable Domestic Animals; London, 1816. A large part of the work is taken up in giving a description of the grasses and other plants experimented on, and in the first edition the illustrations were dried specimens of the grasses themselves. The results of the experiments were useful for purposes of comparison; but as they were not actual feeding experiments, but analyses of the hot-water extract of the different plants, they cannot be taken as giving the actual feeding value of the pastures. After serving the Duke for seventeen years, Sinclair entered into partnership with a firm of seedsmen at New Cross, Deptford, where he died in his forty-eighth year, in 1834. His folio attracted world-wide attention and gained him many honours. He was, before his death, made a Fellow of both the Linnean Society and of the Royal Horticultural Society, as well as of other botanical organizations. He published and edited a number of other works; but while the fame of these has been dimmed, yet the fame of the historic Hortus Gramineus still remains verdant. [A. M.]

Sinclair, Sir John (1754-1835), founder

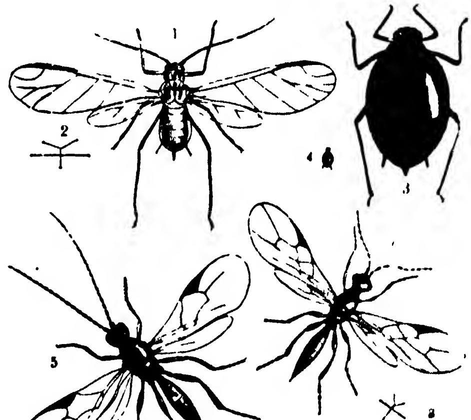
and first President of the Board of Agriculture, was born at Thurso Castle, in Caithness. Educated for the Bar, he early entered the political arena and soon forged his way to the front rank as a politician. His greatest work was the establishing of the Board of Agriculture, of which he was twice President (1793–8, 1806–13). His interests were not wholly centred at Westminster, however, for he did much to improve methods of farming not only on his own estates but all over Scotland. Worthy of special mention also is his work as President of the Special Committee of the Highland Society for investigating the comparative merits of the wool of different breeds of sheep. He was made a baronet in 1786. Sinclair was a voluminous writer, and published many works on legal, financial, and agricultural subjects; and it was through his efforts that the great Statistical Account of Scotland (in 21 vols.) was compiled. [A. M.]

Singling Root Crops.—Certain farm root crops, such as turnips, carrots, and mangolds, have an excess of seed sown, and then by hoe or by hand the plants are reduced till they stand sufficiently far apart to permit of their maximum growth. All crops require a certain space for their full development, and any increase or decrease of the plants above or below what is required tends to reduce the crop. Turnips, swedes, mangold, beet, and cabbages are usually singled when the young plants are from 2 to 3 in. high, and the work is not only better but more expeditiously performed if the plants are thin but uniform. At the proper stage, one person can usually single an acre in from thirty to fifty hours, much naturally depending on the expertness of the workman, the stage in which the plants are, the cleanness of the land, the class of soil, and the care with which the work is done. When singling turnips, &c., the workman uses a light hoe set at right angles to the handle, which should be from 5½ to 6 ft. long. With such a hoe he strikes out the superfluous plants and weeds both by thrusting and drawing, and thereby not only saves time, but does superior work, as he leaves the excess on both sides of the drill. Drills have to be varied in width according to crop, soil, and climate, but with mangolds in 26- to 27-in. drills the plants do very well about 12 in. apart. Turnips are usually in drills 27 to 28 in. wide, and according to variety the plants may be from 12 to 14 in. apart. Some crops, such as carrots, do not single well with the hoe, and they are in consequence generally done by hand. In Scotland, where this crop is extensively grown, it is usually sown with two rows on each drill, the rows being about 5 in. apart. Under such circumstances, singling with the hoe is quite impossible. The singling is therefore done by hand, the plants being left from 3 to 5 in. apart, according to the stage at which it is intended that the crop should be marketed. When carrots are sown in single rows on the flat, and not ridged up as with turnips or mangolds, they are usually left a little closer than where there are double rows on a raised drill. [J. S.]

Siphocoryne capreæ (the Small Willow Aphis), a very abundant aphis on willows and osiers of all kinds. It is found swarming on the leaves and even shoots, spoiling the young rods by causing distortion. The wingless viviparous female is oblong and green, and coarsely punctured. The winged viviparous female is green, with dark-brown head, a band on the prothorax and another behind, the rest of the thorax blackish; the abdomen has olive-green bars; the cornicles long and deep-olive-green; apex of abdomen attenuated; antennæ thin and black; legs pale-green with brown tibiæ and tarsi; the rostrum reaches to the second coxæ. Little can be done for the destruction of this pest in osier beds, but on ornamental willows it may be easily destroyed by washing the trees with soft soap and quassia. Its life-history is unknown. [F. V. T.]

Siphonophora (Long-Siphon Aphides), a large and very important genus of Plantlice or Aphididæ with a long rostrum, very long antennæ, at least as long as the whole body, seated on distinct frontal tubercles. The cornicles are always long or very long, and the legs long and slender. The males are winged, and the oviparous females appear to be mainly apterous. The males can be told from the winged females by having smaller abdomens, longer antennæ, and larger wings. Many are very harmful to crops and flowers. Some of the more important are mentioned here. [F. V. T.]

Siphonophora granaria (the Corn Aphis).—This green fly or dolphin is found on



Siphonophora granaria—Corn Aphis

1, 2, Male, magnified and natural size 3, 4, Female, magnified and natural size 5, 6, 7, 8, Flies (magnified and natural size) destructive of aphides by puncturing and depositing eggs.

all cereals and on many wild grasses, and also on Polygonum. In some seasons it is most harmful, and lessens the yield of corn to a very considerable extent. The injury is twofold: first, the plantlice suck away the sap from the blades, and later they swarm in the ears and draw out the moisture from the developing kernels. When on the ears they insert their rostra just at the base of the grains. Sometimes they occur in

such numbers that the ear becomes one mass of lice. Some damage also seems to be done by the actual punctures of their beaks. They go on doing damage until the grain gets too hard for them to puncture. A curious sickly yellow colour results in the attacked ears.

The apterous viviparous female is somewhat oval, wholly green or brownish-green, with brownish antennæ; the cornicles are long and shiny, brown in colour; the eyes are red, the legs stout, femora and tibiæ ochreous, the latter black at the tips, also the tarsi.

These go on producing living young until well into July, when the lice turn into pupæ. As the corn hardens, winged viviparous females occur and go on until the corn is ripe. The winged female is pale-greenish-brown to rusty yellow; the thorax brown with darker areas; the oval abdomen shining-green with four well-marked black dots, and there are three large black dots on each side. Cornicles long, black, thickest at the base; legs ochreous, with black knees and tarsi; the transparent wings are green at the base, and the veins are brown. They mainly attack the late wheats. The female lays its eggs on various wild grasses, and is thought also to live at the roots of winter wheat in the wingless stage. All that can be done for this pest is to keep down all wild grasses near, as far as possible, and to scarify the fields after an attack. [F. V. T.]

Siphonophora pisi (the Pea Aphis), one of the commonest field green fly, and frequently very harmful to field and garden peas. It clusters in thousands on the blossom stalks and causes the death of the blossom, and even when the peas are in young pod does enormous damage. These insects also feed on various wild Lathyri, and on Spiræa and Capsella. They are large green aphides. The only *treatment* is knocking them off on to the ground and destroying them, or spraying with soft soap and quassia, or jarring them off garden peas into jars of paraffin and soap.

Various others do damage, such as the Geranium Aphis (*S. pelargonii*) on geraniums, calceolarias, malvas, and chrysanthemums, &c., and, both under glass, the Strawberry Aphides (*S. fragariæ* and *S. fragariella*). Those that occur under glass, as the two latter, may be destroyed by fumigation with tobacco. [F. V. T.]

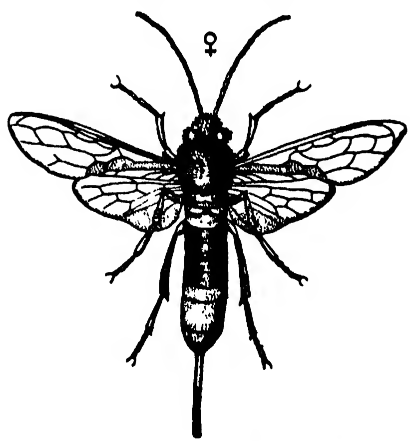
Siphonophora rosæ (the Rose Aphis).—This is the commonest of the three rose aphides, which are an incessant plague to the rose grower. It occurs on the teazle as well as the rose, a migration taking place between the two plants. They damage the rose by sucking out the sap of the shoots, leaves, and unopened blossoms, frequently killing the shoots, and at other times causing deformed blossoms. This species clusters in dense masses, and is specially noticeable from May to July, and again in the autumn and on into the winter in sheltered places, the intervening time being spent on the teazle. This aphis varies in colour, some being green, a few dirty-red or ferruginous. It is quite possible that these two forms are distinct but closely allied species. The apterous female is normally green, but may be ferruginous-red, smooth, with long cornicles, somewhat curved, expanded at the base and black at the tips; legs long, yellowish-green, with black knees and tarsi; eyes red. The pupal stage has brown wing-buds, and is often ferruginous on the dorsum, with four spots on each side. The winged females arising from these have the head and thorax blackish; eyes red; cornicles black and shiny. Legs yellow, with black knees and tarsi. The oviparous female is long, oval, and reddish. The male is winged and very rare.

The eggs are laid at the base of the leaf-buds, and are glued on to the twigs; each female may lay as many as five ova, which occur in winter. At the same time, living viviparous females may go on producing young in warm spells of weather, especially on roses against walls. This species is found on wild as well as cultivated roses.

Two other species of Siphonophora occur on the rose. One is *S. dirhoda*, which migrates to grasses and wheat, and is found on young rose shoots. This is a yellowish-green aphis. The other is *S. rosarum*, which can be told at once by being hairy in the apterous viviparous female.

Treatment of rose aphides is simply spraying with soft soap and quassia or nicotine. Paraffin emulsion should never be used, as the caustic effects of the paraffin are often as harmful as the aphis. [F. V. T.]

Sirex gigas (the Giant Wood Wasp).—This large hymenopteron reaches over 1 in. in



Giant Wood Wasp (*Sirex gigas*)—Female

length in the female, often 1½ in., rather less in the male; the head is black, with a large yellow spot behind the eyes; the abdomen in the male is reddish-yellow, with the first and last segments black, in the female the second and third posterior segments are yellow, the rest deep-black; the legs are black, with yellow knees. The abdomen in the female ends in a strong blunt point, and beneath it is an ovipositor which is long and dark, lying in a yellowish sheath. The antennæ are yellow in both sexes, in the female a little more than half the length of the body, in the male nearly as long as the body. The four large membranous wings have a brownish tinge. The

adults appear in the summer. The female lays her eggs in various kinds of Pines, Scots Fir, Silver Fir, and Spruce.

The damage is done by the larvæ tunnelling into the wood, where they feed. A hole is bored by the female into the bark, and then the eggs are deposited. The larvæ are soft and yellowish-white, cylindrical, with a brown head armed with very strong jaws; there are three pairs of very minute feet, and a blunt process at the tail end; the skin is much wrinkled. The galleries formed by the larvæ reach a considerable length, and become blocked up with a compact core of wood chips. They take some time to grow, usually not maturing until the summer of the third year, when they construct a pupal chamber at the end of the tunnel, lining it with a glazy substance. When the fly is ready to escape, it does so by eating out a fair-sized circular flight hole, which may reach nearly ¼ in. across.

There seems to be considerable variation in the length of larval life, as one frequently finds them escaping from prepared wood, such as imported window frames, boxes, &c. Large numbers frequently occur in the same tree, and the wood is consequently ruined.

Prevention and Remedies.—All attacked timber should be felled and burned in winter, especial care being taken to split and burn the affected parts. It is said that all high stumps and broken wood should be destroyed, and that felled coniferous wood should be removed as soon as possible. [F. V. T.]

Sirex juvencus (the Steel-blue Wood Wasp).—This species is equally common in this

Wood Wasp in the act of Boring, exposed by splitting the wood. (From Schlich.)

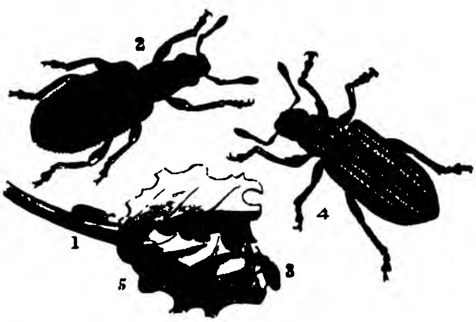
country; it is somewhat smaller than the preceding, seldom reaching more than 1 in. long in the female. The thorax and abdomen are steel-blue, the male having the fourth to seventh segments yellowish-red, whilst in the female the steel-blue abdomen is very iridescent, sometimes with a violet or coppery tinge. The wings are yellowish with a brown margin. The mature insect appears in July and bores its ovipositor into the Scots Pines down to the sapwood, laying a single egg in each hole. The white larvæ at first live on the softer layers of the sapwood, but later bore deep into the trees. The life-history is very much the same as the preceding. Like *S. gigas* it does not confine its workings to any particular conifer, but may occur in Larch, Spruce, Cedar, and others. [F. V. T.]

Sisymbrium (Hedge Mustard and Garlic Mustard) is the botanical name for a genus of Cruciferous plants which produces seeds with a biting taste like the true Mustards; unlike the true Mustards, however, the seeds are flat, oblong or egg-shaped, and not globular.

Hedge Mustard (*Sisymbrium officinale*) is a yellow-flowered annual species, 1 to 2 ft. high, easily recognized by the minute flowers $\frac{1}{16}$ in. in diameter, and by the downy pods (siliqua) pressed close against the stem, shaped like a club ½ in. long, with a minute hollow disk-shaped stigma at the narrow apex. This plant is common on ordinary land, by roadsides, and in waste places. It reaches the flowering stage in June and July. Hoeing and cutting to prevent seeding are necessary and effectual.

Garlic Mustard (*Sisymbrium Alliaria* or *Alliaria officinalis*) is a white-flowered annual or biennial milk-tainting species, 2 to 4 ft. high, flowering before Hedge Mustard in May and June. It affects heavy land, chiefly hedgebanks. The plant is readily recognized by the glossy heart-shaped and toothed leaf-blades of the ground leaves, 3 to 4 in. in diameter; when bruised, these blades emit a strong garlic odour. Cows readily browse Garlic Mustard, and the milk then acquires a strong taste of Garlic. Hence this plant should be cut down whenever it is noticed; if this is done, extermination follows as matter of course. [A. N. M'A.]

Sitones crinitus, Herbst (the Spotted Pea-weevil; see accompanying fig.), is covered with grey and rosy scales and short hairs, but when



Sitones crinitus; 1, nat. size, 2, magnified. Sitones lineatus; 3, nat. size, 4, magnified. 5, Leaf notched by Sitones.

they are worn off the surface becomes black and shining; the head is rather broad, the face elongated and concave, with a line down the middle, and the mouth and jaws at the extremity; the eyes are black and prominent; the two antennæ are slender, angulated, twelve-jointed, and clubbed; the thorax is oval and convex; scutel minute; elytra much broader, elliptical, with twenty punctured lines, with two ample wings beneath; legs rust-coloured; feet longish, four-jointed, and furnished with two claws.

This is one of the weevils which attacks the peas soon after they appear above-ground, in the early spring, and causes such depredations in March and April that crops are frequently worthless, if not altogether destroyed. [It is somewhat local, but generally distributed. It is particularly prevalent in the London district and on the South coast. It is especially partial

to tares. The next species is the chief pea and bean pest.—[F. V. T.]

Sitones lineatus, Linn. (the Striped Pea-weevil) (fig. 3 shows natural size of large female; 4, one magnified). Being much more abundant, this is a more formidable enemy in the pea field than the foregoing species. In form it is similar to *S. crinitus*, but it is covered with scales of a clay-ochre colour, often tinted with copper or green. As the weevils grow old these scales wear off, and their backs are then black and shining. The eyes are black and prominent; the antennæ slender, of a tawny colour, brownish at the extremity; thorax deeply punctured with three pale lines down the back; wing cases with twenty punctured furrows; two ample wings beneath; they have six short strong legs, of a tawny or rust colour.

The weevils come forth with the warm and sunny days of March, having hibernated in all manner of places; and in April their ravages are daily, often hourly apparent, clearing off, foot after foot, the finest plants from 2 to 4 in. high, repeated sowings suffering the same fate; and when the peas, and the beans also, are more advanced, they notch the leaves, as shown in illustration (fig. 5). They prefer the white to the grey peas. They feed all day, but are only found on still dry days. On dull, cold, and windy days they shelter under clods of earth, stones, &c. If approached with great caution, they may be seen feasting upon the tender buds and edges of the leaves; on the slightest alarm, however, down they fall and lie as if dead amongst the clods, which are so nearly of their own colour that to detect them is very difficult, until they stretch out their legs to recover their feet. They usually fall on their backs and feign death.

Their ravages seem to be confined to what are termed papilionaceous plants; for the weevils commence with the peas, then they attack the beans, and finally resort to the lucerne and young clover crops, where they congregate in myriads, notching and riddling the leaves until the approach of winter; and they are often abundant on the furze and broom.

The beetles lay their eggs either upon or just under the soil close to the roots of their food plants. The eggs hatch into small white footless maggots which feed upon the roots of peas, beans, clover, and lucerne, also sainfoin. The larvæ when full-grown measure about ⅙ in. in length, and then pupate in an earthen cell. The adults also hibernate in numbers in barley stacks and in stubble, but chiefly in hedgerows and amongst rubbish. It is these hibernators that attack the early peas and beans and deposit their eggs near their roots. From these eggs larvæ appear which mature by the end of May and in June, and they give rise to the summer brood of beetles. A large number of these lay eggs upon the roots of clovers and lucerne, upon which they live all the winter. These winter larvæ often do much harm to clover, and may give rise to beetles in March or not until May or June. Thus this beetle winters in two ways. The maggots bore channels along the main roots, and are also said to feed upon the nodular growths found on the roots of leguminous plants.

Two other species are often harmful, namely *Sitones hispidulus*, Fab., which is common on clover in sandy districts, a black weevil covered with fuscous-brown scales, the eyes flat and not prominent as in *S. crinitus*. *Sitones humeralis*, Steph., is also abundant in the south of England on trefoils. It is like the preceding, but has a pale patch on each side of the wing cases.

Prevention and Remedies.—In field cultivation the only things that can be done are first to prepare a fine tilth, and secondly to roll the young plant with a light wooden roller, followed by a good dressing of soot. In the garden, rows of attacked peas may with advantage be covered with fine earth such as is discarded from hothouses, or with sand. Spraying the rows with arsenical washes has also been found to be beneficial. Great numbers of beetles are often noticed in the carts when barley is harvested and when it is being threshed; these should be collected and destroyed. Infested clover leys should be deeply ploughed with a skim coulter on the plough and well pressed. Summer fallowing of land after an attack is desirable. [J. C.] [F. V. T.]

Sitotroga (Scardia) granella (the Grain Moth).—This small moth, one of the Tineinæ, is often harmful to stored cereals in Europe and America. In this country it attacks stored grain, but it is also said to attack grain in the field. The damage is done by the small caterpillar, which goes from grain to grain, and these it spins together with its silken webbing. It is said as many as twenty or thirty grains are ruined by one caterpillar, but much more is really harmed, as they move all over the grain when nearing maturity and cover masses with their silk. The moth is a little less than ½ in. in wing expanse; the fore wings are creamy-white, and have deep-rich-brown spots, six on the costa, and on the inner margin a brown oblong spot. When at rest the wings close like a roof over the body, with the fringe curved upwards. Besides corn they are said to attack timber, books, woollen stuff, &c. Stainton records the moth in September and October; it also occurs in April and May. In warm granaries it has been found all the winter.

Prevention and treatment consists first of all in thoroughly cleansing the granaries by sweeping out all refuse, not only on the floor, but on walls, roof, &c.

In dark granaries the moth may be killed in enormous numbers by placing a bright light in them in May, or again in September or October. The moths fly to the light and are burnt. Other plans adopted are kiln-drying the affected grain at about 89° F., and fumigating with disulphide of carbon as for grain weevils. The main thing is cleanliness. [F. V. T.]

Skim Milk.—The term 'skim milk' is applied to milk from which the bulk of the cream has been removed; so that skim milk differs from whole milk practically only in the percentage of fat. Skim milk is the by-product in the preparation of market cream or in butter-making where only the cream is churned. Two

distinct methods of removing the cream are practised: (1) by taking the milk warm from the cow and setting it in pans, allowing the fat globules to rise to the surface under the action of gravity; (2) by subjecting the milk to centrifugal force in the cream separator. The skim milk obtained by the gravity method is termed 'skimmed milk', and that obtained by the centrifugal method 'separated milk'. The distinction is chiefly one of degree. In skimmed milk, wide variations are found in the percentage of fat, which may vary from ·4 to over 2 per cent, according to the temperature and other conditions under which the milk is set, the size of the fat globules in the milk, and the care or skill in the removal of the cream. Much lower percentages are found in separated milk: with modern machines there need not be more than ·1 per cent, and the limits ·05 to ·3 per cent are very rarely overstepped. By the gravity method the milk stands for twenty-four hours or longer, and the solids not fat become partially changed by the action of micro-organisms. In the centrifugal method the milk is separated in a perfectly fresh condition, so that the solids in the separated milk are practically unchanged. By the centrifugal method many of the germs and filth particles are driven against the wall of the separator bowl and removed in the separator slime, but in the gravity method most of the solid impurities remain in the skim milk.

By removal of most of the fat, the percentages of the other solid constituents in milk are slightly raised in amount. The following may be given as the average composition of skim milk and separated milk respectively:—

	Skim Milk			Separated Milk.	
Water ..	89·85	per cent	......	90·45	per cent
Fat	0·75	,,	......	0·10	,,
Albuminoid matter	4·03	,,	......	3·9	,,
Milk sugar	4·60	,,	......	4·8	,,
Ash	0·77	,,	......	0·75	,,

The specific gravity at 15° C. of skim milk is 1·034, and of separated milk 1·035.

Skim milk contains all the nutritive qualities of the milk except the fat; an average of 9·5 per cent of dry matter, practically the whole of which is digestible. The Board of Agriculture in 1901 made a regulation to the effect that 'where a sample of skimmed or separated milk other than condensed milk contains less than 9 per cent of milk solids it shall be presumed for the purposes of the Sale of Food and Drugs Act, until the contrary is proved, that the milk is not genuine'. On account of its high nutritive qualities skim milk is a valuable foodstuff either for human consumption or for animals.

The market value varies very widely. Being a dilute and heavy commodity, the cost of transport to any distance is comparatively great, and the best returns are obtained where it can be retailed locally. Skim milk is used also in the manufacture of margarine, but the manufacturers prefer to purchase the whole milk and separate the cream for themselves. Casein of milk in the dried or in other forms is used very extensively in the arts and manufactures, and is most readily and cheaply obtained from fresh separated milk. Condensed skim milk is also prepared and put on the market on an extensive scale, large quantities being imported into this country annually. Skim or separated milk supplemented with suitable meals is a capital diet for calves after a few weeks old, and for growing and fattening pigs. There is a popular favour for skim milk as against separated milk for this purpose, on account of its higher contents in solids. But the separated milk is the sweeter and more wholesome article, having undergone less fermentation in its preparation. [W. ST.]

Skim-milk Cheese, as its name implies, is cheese made with milk from which the fat has previously been abstracted. The product, though poor in fat and lacking that mellow flavour and meatiness characteristic of cheese made from whole milk, is nevertheless, when properly made, a wholesome and nutritious article of diet. In many parts of America the making of skim-milk cheese is largely practised, especially among cottagers, where it is known by the names of Dutch cheese, cottage cheese, or Schmierkäse. The American method is as follows: the milk is allowed to sour, but if desired this can be hastened by keeping at a temperature of about 80° F. until coagulated. It must not be allowed to stand too long, or the curd will become soft and mushy in consistency and sour in flavour. After coagulation, gradually raise the temperature and stir the curd, thus breaking it into small pieces, so that the moisture is more easily and rapidly expelled. The temperature should be raised to 120° F., while the stirring is continued until the curd is sufficiently firm, after which it is allowed to settle. The whey is then run off, and the curd placed in a cloth strainer, which may be suspended, so that the excess of whey is allowed to drain from the curd. This may be assisted by occasional stirring. When sufficiently dry the curd is salted, and put up in various forms for the market. Cheeses so made are acid in character.

In this country the process of manufacture resembles very closely that of the Scotch Cheddar. There are, however, several important and essential points of difference, which must be carefully studied in order to obtain cheese of good quality. The quality of skim-milk cheese depends largely on the amount of moisture retained. There should be about 75 per cent in the curd, and this produces a smooth cheese of good texture. Above this amount it is apt to be soft and sticky, while with less moisture it is harsh, dry, and gritty.

In making, allow the milk to stand at a temperature of from 80° to 85° F. until sufficient acid has developed, then add enough rennet to coagulate in from twenty-five to thirty minutes. When firm enough to cut, use the perpendicular and horizontal knives as in the Cheddar, but do not cut so fine, the object being to retain a large amount of moisture. For the same reason, also, lower the temperature of the scald, which should not exceed 90° F.

The amount of acidity in the curd at the time of drawing the whey is also an important point, and like spring-made cheese, considerably less

should be allowed than with ordinary summer-made Cheddars. This may increase the length of time required to mature before milling, but the extra moisture retained very materially assists the ripening process. Do not remove the curd when the whey has been drawn, but pile it up on each side of the vat, to begin with. Afterwards tie it into a cloth and allow it to lie until ready for milling. After milling, leave it to mature well before salting, in order to obviate its tendency to openness and toughness. Mix salt uniformly and stir until fully dissolved. As the curd contains little or no fat, less salt will be required. Instead of from 2 to 2½ lb. salt to 100 lb. curd, as in the Cheddar, use from 1 to 1½ per 100 lb. After adding salt, keep up the temperature at 80° F. until placed in the hoops. If too cold, more especially in the absence of fat, it is difficult to get the particles to adhere. When put into press, allow pressure to be light for the first few hours, and gradually increase. This gives a better separation of the surplus moisture. The temperature of the curing room should be higher than for whole-milk cheese, and should range from 65° to 75° F.

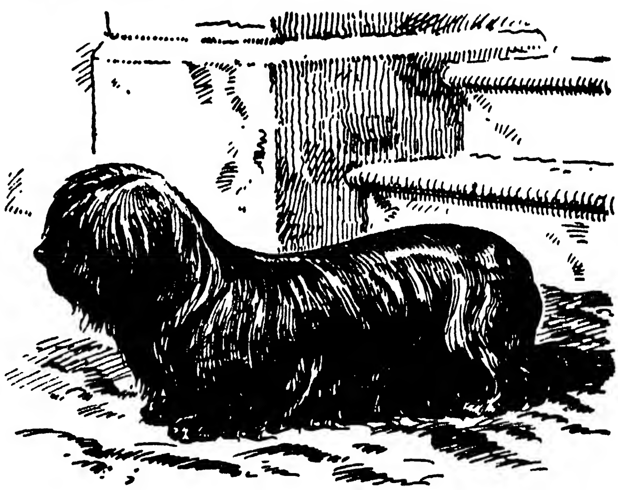
[D. K. R.]

Skin Diseases.—A number of eruptive skin diseases which are called exanthemata, blossom out from specific constitutional maladies such as smallpox, cow pox, foot-and-mouth disease, or from local irritations, or, as in urticaria, from quite evanescent disturbances of the digestion or circulation. Of the primary exanthema we find examples on the nude skin of the dog and cat, and with more difficulty upon larger animals; the marks being due either to anomalous conditions of the bloodvessels, or to white, yellow, brown, or black pigmentation. A simple redness either in circumscribed areas or generally over the hairless skin, as when a dog is picked up out of the snow, is known as erythema, and may quickly pass or result later in some vesicular eruption which would be called eczema. Recognition of patches of discoloration and their significance is of greater importance than the student, impatient of scientific verbiage, is at first willing to concede; as, for instance, the hæmorrhagic patches under the skin may be diagnostic of that frequently fatal disease purpura hæmorrhagica, or of symptomatic anthrax (see BLACK QUARTER). Petechial spots or ecchymoses (diffuse hæmorrhagic) are symptoms of blood diseases, as scarlatina, and must be distinguished from pigmentation, so frequently seen in the dog, and for some unexplained reason most commonly in dogs with any blueness in their coats. Nodules or papules are elevations of the skin of varying size and propinquity, and are due either to local inflammation and new tissue formation, or to retained secretions. Common examples are found under the collar and harness of horses where the sweat glands are interfered with by pressure, while inflamed by retained salts and debris; finally, the papule or nodule, which might be called a pimple but for the confusion in the lay mind, is distinguished from the vesicle by containing no free fluid. The so-called blind boils which never come to a head, and, if not worried, slowly disappear, are true pimples or papules. The vesicle is a blister in miniature, or, putting it the other way about, a blister is a large vesicle. It may be of any size, and has some sort of relation to the size of the species of animal. The vesicles of simple eczema will be very much larger on the thighs of the ox than on those of the little dog or cat. They are, however, constituted alike. The pustule is an accumulation of pus under the epithelium in like manner to that of a vesicle, but caused by suppurative infection. It may be first observed as a pustule, or have passed through the vesicular stage, as in the various forms of variola (see PUSTULATION). The specific eruptions, like cow pox, have certain well-defined periods, beginning with an elevation of the skin and then constituting papules, next vesicles, then pustules, and finally undergoing resolution and desquamation of the cuticular covering. The presence of any skin elevations, when infectious diseases are rife, will call for special observation on the part of the stock-owner, who will be in a fair way to diagnosis if he keeps in mind the distinctions we have above attempted. If the papulations come to nothing after the lapse of a given time, he will know that he has not dealt with cow pox, or that terrible malady in the fold, sheep pox. Nettle rash or blotch (see NETTLE RASH) differs from those distensions already mentioned, in being a simple serous exudation under the surface layers; and its rapid absorption and disappearance distinguish it from the papule, the vesicle, and the pustule.

Eczema under its more common forms has been described (see ECZEMA), but the bran-and-scale eruption sometimes called 'hunger mange' may here be considered. Although dirt and poverty, and that absence of fat under the skin that denotes health and is recognized as 'bloom' by horsemen, are associated with it so much as to give the name of hunger mange, it is not confined to the poor and ill-kempt. There is a persistent accumulation of scales, having something of the appearance of bran, but more transparent and lighter in colour and weight, with the skin underneath discoloured, hardened, and thickened, but with no more than a slight irritability, as evinced by occasional rubbing. Around the eyes, inside the ears, upon the neck, shoulders, the elbows, and root of tail, and in the bends of the knee and pastern joints it is most observed, and frequently associated with that form of eczema known as mallenders and sallenders (which see). The disposition is to become chronic, but natural healing or recovery takes place sometimes in altered circumstances of life. Pityriasis, or branlike excess of cuticle or scurf, is not necessarily associated with the disease above described, but seems only like the excessive dandruff of human subjects. *Treatment* is either palliative, by supplying unctuous materials, as lanoline, and washing with alkaline soaps, which for a time clean the surface by lifting the partly desquamated cuticle; or provocative, by which we mean stimulated into an acute form, after which repair takes place in some but not all cases. Creolin and tar have this effect, as do chrysarobin and ichthyol oint-

ment. The loss of hair from the tail, commonly called rat-tail, is attributed to a disease of the skin known as chronic impetiginous eczema, and peculiar to the long-haired parts, including therefore the mane. It is frequent in eastern Europe, where superstitious objections are held to proper hygiene. Too much grooming and irritation from mane comb and dandy brush, and frequent washings with soft soap, are also said to give rise to this skin trouble which ends in the loss of hair. The writer is inclined to think there is some other reason for rat-tail, as no history of disease attaches to the many affected tails we meet. It may have some association with temperament. Certainly it occurs in horses with no disposition to rub; and those which do so have usually thick bushy tails, merely made ugly by the habit, not bald. The coal-tar preparations are recommended as allaying the irritation. A 3-per-cent carbolic lotion, with a like proportion of glycerine in water, has been found comforting to itchy subjects. The skin diseases affecting the flexures will be found under MALLENDERS. The multiplication of epithelial scales into pyramidal and other forms might be considered here, but will be more conveniently treated under the heading of WARTS. Alopecia, or the falling-out of hair without any apparent disease of the skin, occurs to animals as to men, and the explanation is yet to seek. Bloody sweat is mentioned in some veterinary works, but the blood does not come through the secretion of the sweat glands, and it is therefore a misnomer. Some skin bleedings are due to parasites (*Filaria hæmorrhagica*), some to septicæmia, anthrax, and acute exanthema. Blood spots in single drops upon the neck, breast, and shoulders suddenly appear. Ergot, sugar of lead, and tannic acid internally are advised, and antiseptic and soothing lotions to the skin. A suppurative inflammation of the skin follicles will be found under ACNE. The ringworms caused by vegetable parasites are described under RINGWORM, and suitable treatment advocated. There is a contagious form of acne called horse pox, with the prefix Canadian, as it was first observed in England on horses imported from the Dominion. The filaria and the contagious acne, ringworm of different kinds, mange in horses, cattle, and sheep (scab), need not be considered here, as they are fully dealt with under their respective headings as infectious parasitic diseases. A gangrenous dermatitis, or local death of skin, is due to the action of external irritants. Solar heat and hot dry winds cause gangrene of the skin of white animals unprotected by saddlery or other coverings. Pigmentation affords resistance to other irritants besides the thermal red rays, and white or light-coloured horses should not be chosen for countries within the tropical belt. [H. L.]

Skye Terrier.—Of late years the popularity of this ancient Caledonian breed of terrier has rather diminished, owing to the support that has been accorded to the Dandie Dinmont and the Hard-haired Scottish Terrier. The fact, too, that the exhibitors of Skyes have unwisely encouraged a type of dog that is practically unfitted for vermin hunting and have neglected the working type, has no doubt caused the variety to be regarded more as a lapdog than as a real terrier, which is much to be regretted, as the true Skye is a plucky, useful little dog. The great difference between the two types is the coat, which in the case of show specimens is cultivated to an extent that renders it as profuse as that of a Yorkshire Terrier, and causes the dog to be quite unfitted for work underground or above it. On the other hand, the jacket of the working type of Skye is short and hard. Consequently it is capable of keeping its owner's skin protected from the effects of cold and damp, instead of acting as a sponge for the accumulation of moisture and impeding the dog's movements as the long one does. The skull of the Skye Terrier is of good length, a peculiarity of it being that it is broader in front than it is at the back; the jaws are powerful, the teeth large and regular, and the eyes dark and not too large. Two shapes of ear are found in the breed, namely, the drop, which lie flat to the sides of the head, and the prick, which stand up erect and are adorned by a liberal patch of hair. The neck is of a nice length, the body extremely long, and the legs very short, the front ones being straight; while the tail, which is never cut, should be carried rather low. The coat, if a long one, should be profuse all over the head and body and quite free from curl, whilst that of the working type is much shorter and very close and dense. Steel-grey is the most favoured colour for show purposes, but some very good fawns have been exhibited. The average weight is about 18 to 20 lb. [V. S.]



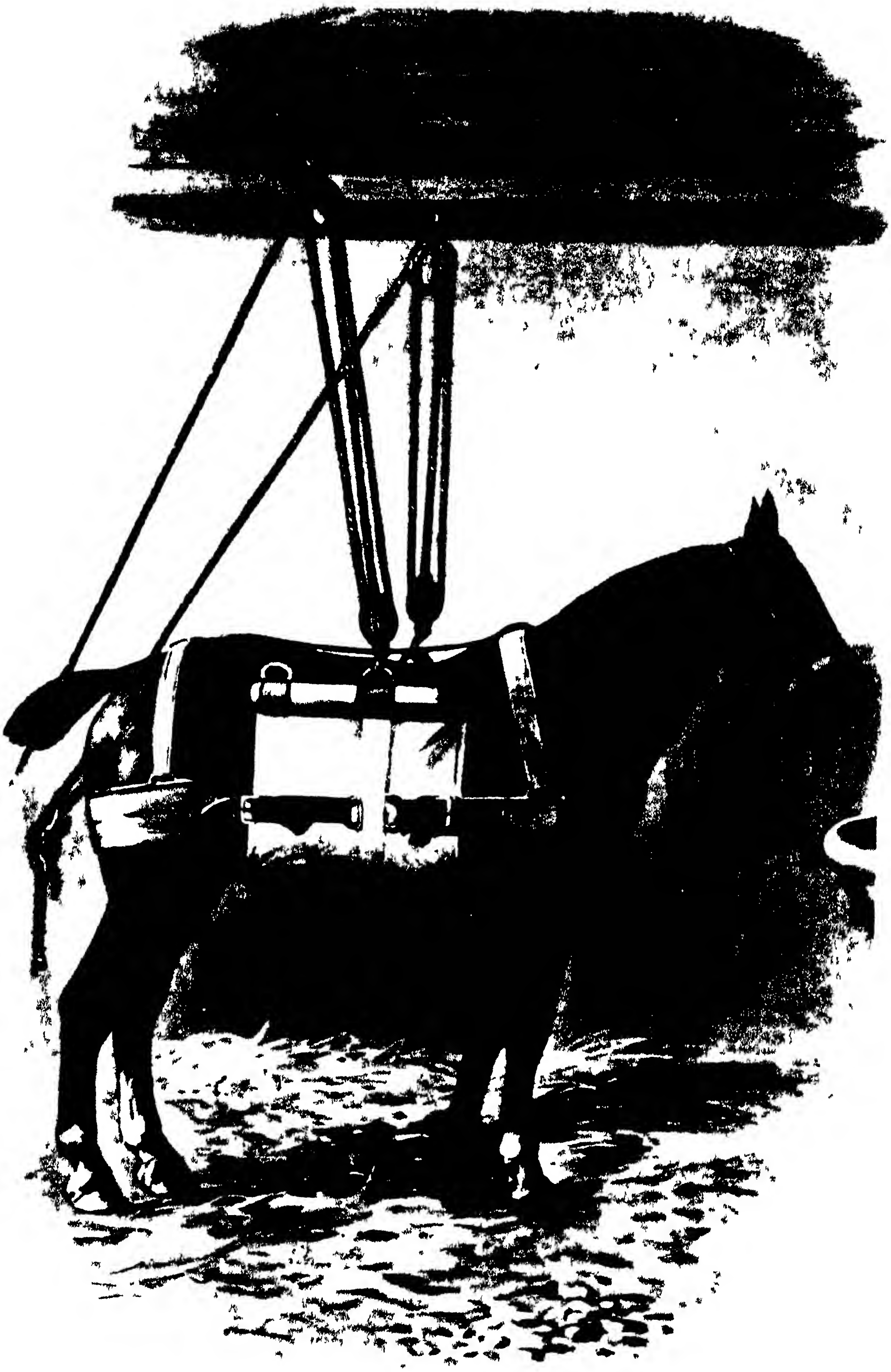
Skye Terrier

Skylark. See LARK.

Slate, a highly compressed and fissile form of clay rock. Shale may pass into slate through the pressure exerted by strata piled upon it. But in most slates the characteristic parting takes place along planes that have no connection with those of bedding, and the latter may even become completely obscured. The particles of a clay are mostly of a minutely platy form, and are so small that they lie lightly against one another in all manner of positions, much as they fell during the deposition of the rock as a sediment. But, when pressure is brought to bear upon the mass in the interior of the earth, the particles become squeezed together, the interstitial spaces are reduced or done away with, and the tiny platy forms become turned round until they come to rest with their broader surfaces perpendicular to the direction along which the compressing forces act. Any new minerals, moreover, such as mica, which develop during this process, tend to grow most easily in directions perpendicular to that from which the pressure comes; and the rock finally receives a new structure, a *cleavage*, along which it splits with more or less regularity. Fine-grained clays may thus pass into excellent hard slates, like those of North Wales. Fossils become obliterated, and the only traces of the original bedding may be the colour-bands crossing the cleavage, which are known to quarrymen as *stripe*. Well-cleaved slates are of special value for roofing, owing to the possibility of employing lighter timbering than is required to carry the coarser types of tiles. Slates containing iron pyrites are to be avoided, since the decay of the mineral may leave a hole right through the slate. Some well-bedded limestones split into layers which can be used for roofing, and are locally known as slates. The Cotswold villages are largely roofed with picturesque but heavy material of this kind.

The *soil* on slates is similar to that on shales, though the material disintegrates more slowly, and yields numerous sharply edged flakes in the subsoil. Commonly a yellow clay soil results, whatever the colour of the originating slate below. [G. A. J. C.]

Slaughter-houses.—The importance of properly conducted slaughter-houses is now happily recognized by local authorities, but there are still in the country many very unsatisfactory buildings in which the business is conducted. The public abattoir has practically done away with the need of private slaughter-houses in our great centres of population; and those who have seen them must agree that the planning and arrangements are excellent, and the charges so moderate as to compare advantageously with the rent or maintenance of any ordinary private house for killing animals. For those who would erect or must maintain slaughter-houses there are a few essentials which may here be mentioned. The floor should be hard and unabsorbent, highest in the middle, with open gutters. A metal ring fixed in the floor at the time of laying it, is preferable to one in the wall, for pulling down beasts, and a catch pit for blood may be inside or outside of the killing chamber. If it runs through a 6-in. drain pipe into a 5-gallon bucket placed in the pit or well, it can be better dealt with than if free in the well itself. The walls should be of glazed brick for 5 or 6 ft. from the ground, and the roof should be 15 ft. or more in height, in order to afford the headroom so necessary to haul up a heavy carcass and skin it in the best position for the operator. Light should be admitted only from the roof, and that from the north-east; the building having a south-west and north-east aspect, so that direct sunshine will not enter. A proper slaughter-house will be fitted with overhead trolley, on which the carcass is simply run along into the hanging shed, which in public abattoirs is on the farther side of a paved court wide enough to admit horses and carts. A brief description of a model public abattoir, such as that provided by the Brighton Corporation, may be worth while. There are railway sidings looping up the whole railway system of the country, where the tailboards of the trucks come out on the level, and as many as ten can be unloaded at once, and the animals driven into pens opposite, and from thence into fasting lairs, where they are allowed to remain for forty-eight hours before a lairage charge is made. After this time a charge of 6*d.* per day is made for a bullock, 3*d.* for a calf, and 2*d.* for a sheep or lamb. So-called private slaughter-houses can be rented by the large butchers; and public ones are provided where everything but the sticking and skinning knife is lent at the low charge of 1*s.* for a beast, 6*d.* for a calf, and 2*d.* for sheep or lamb. This building is 54 ft. by 18 ft., with eight bays; the crotches for sheep are zinc-lined, and therefore easily cleaned. Separate buildings exist for swine, with comfortable pens. 'Pig keeping' is discouraged, but a sensible consideration is shown for owners who are not forced to glut a full market, and enjoy much the same privileges as they would in their own private slaughter-houses. At Islington and Deptford, cold storage has been added; and this, we think, should be provided in every public abattoir. In the killing-house, sticking-down places are made in the floor, and on a slope, so that the blood runs into a bucket in the same way as described in connection with cattle and sheep, and the carcass is run along on rails to scalding tanks heated by steam, and a regulated heat is afforded, so that fine-haired breeds can be submitted to a temperature of 165° F., or thick coarse-haired ones to 175° F. or 180° F.—a great advantage over the uncertain copper of the cottager. From thence the finished carcass is run on rails to the hanging room, where a couple of hundred make no great show. A tripe house with spare boilers is also provided, and the users pay less than fuel would cost them at home. There is also a hide house, where numbered hooks prevent confusion. The large and small intestines are sold with the œsophagus, and a farmer contracts for the blood and contents of the stomach and bowels, which are carted away several miles and utilized as manure. Slaughter is permitted at all hours during the week at the Brighton abattoir, and until ten on Sunday mornings. There



SIMPLE SLINGS

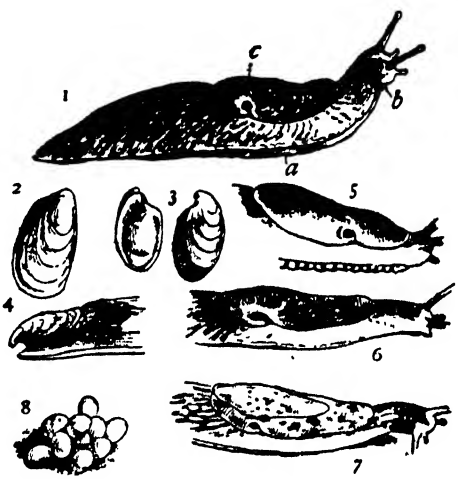
is every inducement to the honest butcher to use the public slaughter-house, and only the 'crooked' man fears the careful inspection made of carcasses before they can be sold for the food of man. For the various methods of slaughter, the reader is referred to the art. ANIMALS, SLAUGHTER OF. [H. L.]

Slinging.—Many lives have been saved by the judicious employment of slings. Veterinary surgeons usually keep a set for emergencies, and the owners of large studs of horses deem them a necessity. In order to raise a horse, the middle piece of the sling must be drawn under his shoulders, lifting them and pulling under a little at a time. His great weight cannot be lifted whole, but by rolling and lifting at the same time no insuperable difficulty is found. When the breeching and the breastband can be made fast to the loops or buckles, the overhead attachment can be applied and the animal hauled up. Most horses struggle to their feet as soon as they find their bodies being raised, and there is consequently no long dead-pull. The endless chain is of great service where numbers are short, as the men can rest while it grips, and renew their efforts. Improvised slings may be employed until more lasting ones can be obtained. Sacks nailed on to an old pair of cart shafts, and ordinary pulleys and wagon ropes, can be made to answer the purpose. Some men succeed with a farm cart, drawing it over the prone animal and raising the ends of the shafts by means of ropes and pulleys from a beam overhead, or three poles on the ground *à la* gipsy camp kettle. Every care should be taken, by stuffing with grass or other material, to avoid 'bed' sores. Cattle do not profit so much by slings, on account of their voluminous stomachs being pressed. On the other hand, they do not so much need them. Horses die if left on the ground for a few days. Bullocks may live for weeks without rising to their feet. [H. L.]

Slipcote Cheese.—This variety of cheese is made from new milk, and at one time was sold by farmers' wives at the door of the customer or in the marketplace on large cabbage leaves. The size of a Slipcote cheese is similar to that of a dinner plate, while the thickness is about ¾ in. It is a simple curd cheese, made by renneting the whey at a comparatively low temperature, turning it from day to day until it is actually ripe. Two gallons of milk will make a cheese nearly 3 lb. in weight. The milk is placed in a wooden vessel and the rennet added at 80° to 85° F., the higher temperature being adopted in the colder weather, and the lower during the warm weather of the summer. The quantity of rennet required depends upon its strength, for the various makes of rennet differ materially in this respect. The curd should be brought in about two hours, and removed into a shape, which gives both size and form to the cheese. This shape may be of tinned iron about 2 in. in depth. It is placed upon a large straw mat, which, in its turn, is placed upon a board. When the curd is firm it is not cut in the ordinary way, but removed in slices into the mould, care being taken to prevent each slice breaking. If the temperature of the apartment in which the work is performed is about 60° F., the whey will gradually drain from the curd, and in a few hours leave it sufficiently firm to be turned; in this case a mat is placed at the top of the mould with a board behind it, although there are some makers who prefer to use a cheese cloth instead of a mat. Turning is continued from time to time until the cheese is firm enough to be removed from the mould; it is then placed upon a clean mat or cloth laid upon a board, and turned occasionally until it ripens. It is fit for sale and consumption when a change has been effected, rendering the curd soluble on the palate, with a delicate and beautifully developed flavour, although in the ordinary way the Slipcote is kept before bringing to table until it commences to run and the coat can be removed. [J. LO.]

Slit Planting. See art. PLANTING.

Slugs.—The slugs or Limacidæ are terrestrial animals and feed on all manner of substances. Most prefer a green diet, devouring the leaves of plants, but some feed upon dry vegetable substances, and others will even eat meat. Slugs are true mollusca, but are not provided with an external shell. The shell of a slug is in the form of a small flat plate buried under the skin in the front dorsal region of the body. Slugs have a distinct mouth, composed of an external fleshy lip and, within, an apparatus the chief part of which is a ribbon-like mass of teeth (the radula), by means of which they rasp away the plant tissues. The body of a slug is elongated and rounded above, flattened below; the flat portion is called the foot. On the back is an oval area, the site where the shell is hidden; near this is seen a hole, the breathing pore. Besides the radula there are two tentacles on the head which are retractile.



1, Common Grey Field Slug (*Agriolimax agrestis*) *a*, foot; *b*, mouth; *c*, breathing pore. 2, Shell of *A. agrestis*. 3, Shells of *Testacella haliotidæ*. 4, Tail end of *Testacella* showing shell. 5, Shield and respiratory pore of *Arion*. 6, Shield and respiratory pore of *Limax*. 7, Shield and respiratory pore of *Milax*. 8, Eggs of *A. agrestis*.

The skin of slugs contains glands which secrete a copious mass of slime; this slime varies somewhat in different species. This slime protects them, and it can be discharged in quite large quantities at least twice in succession, and this is done if an irritant is put on their skin. The most general and destructive slug in Britain is the Common Grey Field Slug (*Agriolimax agrestis*). It is most prolific, and occurs alike in garden and field. A single slug may lay as many as 500 ova during the year. The eggs are white and opaque and oval, and are laid in batches of from six to fifteen. They hatch in from three to four weeks into small slugs like the parent, but paler in hue. When first hatched they are no more than $\frac{1}{16}$ in. long. The eggs are laid from May on to November in the soil and under stones, tiles, boards, &c., on the soil. The adults live through the winter, taking shelter under stones, pieces of wood, in the soil, &c. If the weather becomes warm in winter they soon crawl forth and eat what they can.

Several other slugs occur and are injurious, as the Root-eating Slug or Bulb Slug (*Milax sowerbii*), which comes out only at night. It feeds off the underground parts of plants, and often attacks bulbs to a serious extent during the day. It pulls leaves into the soil like a worm. It will also attack insects, earthworms, and smaller slugs. It is keeled along the back. Large Black Slugs (*Arion ater*) often reaching 4 to 4½ in. in length also occur; this kind is chiefly seen along dykes and ditches, but also invades gardens and does much harm if it gets amongst seedling plants.

The Yellow or Household Slug (*Limax flavus*), a large species, is often found indoors, in cellars, sculleries, &c. It will feed on cream, meat, and flour. It has a bluish head and tentacles, and the body is often speckled.

The length of life of slugs is very varied. Some, such as the Black Slug, may live for four or five years.

Slugs with a small external shell, known as Testacellæ, are beneficial to some extent, for they feed on underground insects, but at the same time destroy the very useful earthworms.

Treatment is very difficult in the field; perhaps the best that can be found is dusting with hot lime on two occasions at a few hours' interval on a wet day. Vaporite, a patent preparation, has been found most fatal to these pests if well broadcast and worked into the soil.

On a small scale in gardens slugs may be trapped by placing hollowed tubers or even hollowed oranges near the affected plants or borders. Slugs may be kept off rows of peas and beans by spreading barley awns over them. They may also be poisoned by placing here and there masses of bran mixed with arsenic in any form, such as paris green, or arsenate of lead.

[F. V. T.]

Small Holdings.—A small holding is defined by statute to be 'an agricultural holding which exceeds 1 ac., and either does not exceed 50 ac., or if exceeding 50 ac. is at the date of sale or letting of an annual value for the purpose of income tax not exceeding £50'.

Small holdings have existed in Great Britain in considerable numbers from the earliest times. Prior to the beginning of the 19th century they were undoubtedly more numerous in most parts of the country than they are at the present time; but various causes, partly legislative and partly economic, have been responsible for the absorption of a large number of them. The most recent return of the distribution of agricultural land in holdings of various sizes (Cd. 8243 of 1896) shows that, in 1895, 4,899,415 ac. in Great Britain consisted of holdings between 1 and 50 ac., and that this represented 15 per cent of the total quantity of agricultural land. If, however, we examine the returns of the number of agricultural holdings, we find that about two-thirds of the total number of holdings are less than 50 ac. in extent, the actual number of such holdings in 1908 being 339,913, or 67 per cent of the total number of separate occupations of agricultural land. It must not, however, be assumed that there are nearly 340,000 smallholders, in the strict sense of the term, in Great Britain. The returns are swelled by the inclusion of a considerable number of small residential properties which have a few acres attached, but which are not farmed for profit, and the occupiers of which are not smallholders in the ordinary acceptation of that term. The returns received by the Board of Agriculture show that, in 1907, 94 per cent of the total number of holdings were 'farmed for business', and this would reduce the number of small holdings proper to 319,600. Of this number, 88 per cent, or 271,248, were rented by their occupiers, leaving 48,352 as the number of peasant proprietors. The number of smallholders is further reduced by the fact that in some parts of the country it is not uncommon for one man to occupy a number of different holdings, which are included as separate occupations in the returns.

The principal cause of the diminution in the number of small holdings was the enclosure of the commons, which took place on so large a scale in the latter half of the 18th and the first half of the 19th centuries. Over 7,500,000 ac. were enclosed between 1760 and 1867, or one-third of the total area under cultivation in the latter year. While it is no doubt true that the enclosure of the commons tended towards improved methods of agriculture, it was done at the cost of the small man, who in most cases lost his right of turning out stock on the commons and of obtaining free fuel and litter. In spite of the fact that in the General Enclosure Act of 1845 certain safeguards were inserted to protect the rights of peasants and the small commoners, we find that, out of 614,804 ac. which were enclosed between 1845 and 1869, only 2223 ac., or one-third per cent, were allotted to the labouring poor. As was pointed out by the Select Committee on Small Holdings in 1890, the compensation received in the form of a small freehold could be parted with, and might pass out of the smallholding class, whereas 'the continuous existence of common rights was a continuous stimulus to the creation and maintenance of small holdings in the neighbourhood'. Evidence of the truth of this is afforded by the fact that where common rights still exist, as for

example in the New Forest, a considerable number of small holdings are still to be found. A diminution in the number of small holdings, especially in the case of those whose occupiers were also the owners, was fostered by the boom in agriculture which occurred in the 19th century owing to the high prices which were obtained for agricultural produce during the Continental and American wars. The result was a considerable appreciation in the value of land, and many of the peasant proprietors were tempted by prices which gave them an income in excess of what they could obtain as cultivators, and their holdings were bought by the adjoining landlords. In addition, the rage for farming on a large scale led many landowners to adopt a policy of consolidation of holdings, and the higher wages obtainable in the towns attracted the pick of the agricultural population to join the rural exodus and forsake the country.

In spite, however, of all these causes, there still remain in certain parts of the country a considerable number of ancient small holdings which have survived till the present day. This is notably the case in the Isle of Axholme in Lincolnshire, where the land is almost entirely held by peasant proprietors. In the parish of Epworth, out of 254 holders of land, 226, or 89 per cent, hold under 50 ac., and most of them are freeholders. The success of these small holdings is mainly due to the fertility of the soil, which is especially suitable for growing potatoes, and a large number of the holders obtain their whole living from holdings of from 10 to 20 ac. In this district exceptional facilities have always existed for small men to acquire land; there are no large landowners, and there has been practically no consolidation of holdings. A man without capital can readily rent a small plot of land, and after a few years he is usually able to save enough to purchase a holding. Land sells at from £60 to £70 an acre, and it is estimated that a net profit of about £60 a year can be made on a holding of 10 ac. There is a strong desire in this district for the ownership of the land, and tenancy is looked upon as only a stepping-stone towards acquiring the freehold.

In recent years there has been in certain parts of the country a natural development of small holdings unaided by legislation. These holdings have in most cases been a result of the great development of fruit growing and market gardening, which has been adopted in consequence of the low prices of corn. The production of fruit and vegetables involves closer and more intensive cultivation than wheat growing, and this fact makes these industries specially suitable to smallholders; while the failure of many of the large farmers who adhered to the traditional methods of agriculture placed on the market a quantity of land which the owners were only too ready to let to small men, who could afford to pay at least as much and usually more rent than the large farmers had done. Typical examples of small holdings which have been so established may be found in the Evesham district in Worcestershire, in the neighbourhood of Wisbech in Lincolnshire, at Tiptree in Essex, at Calstock in Cornwall, and at Blairgowrie in Scotland. In the Evesham district more than 10,000 ac. are held in holdings of from 1 to 8 ac. Rents range from £3 to £6 an acre, and as much as £10 an acre is paid for good grass orchards. The smallholders mostly rent their holdings, and under the Evesham custom an outgoing tenant obtains from the incoming tenant full compensation for all his improvements. Hundreds of families in this district are obtaining their whole living on holdings of 5 or 6 ac., and it is said that the various fruit and vegetable crops grown will yield from £20 to £50 an acre per annum. The success of the holders in this district is mainly due to the good soil and the early climate, coupled with the facilities for the disposal of produce, and the security which the Evesham custom gives to the expenditure of capital on the land.

The district round Wisbech was formerly almost entirely devoted to wheat growing, but there are now nearly 5000 ac. under fruit within seven miles of the town. Most of this land is in the hands of smallholders, the majority of whom own their holdings. Nearly 15,000 tons of fruit are dispatched every year from Wisbech station, most of which goes to Manchester and the north; and the principal crops grown are apples, plums, bush fruit, and asparagus.

The small holdings at Tiptree, in Essex, which number over 200, are mostly devoted to seed growing, and a man can entirely support himself on 6 ac. About £20 an acre is an average return per annum. The success of these holdings has been largely due to the presence of a jam factory, which affords a great deal of work in the picking season, over £10,000 a year being paid in wages. It is therefore possible for a man to start with an allotment of 1 rood, and gradually increase his holding till he is in a position to give up working for someone else and devote all his time to his own holding.

At Calstock, in Cornwall, there are a number of small holdings on which fruit and flowers are grown for the London market. Here the climate and the sheltered position result in early ripening of the fruit, and 5 ac. is sufficient to support a family. There are a large number of small freeholds, but much of the land is tenanted at rents varying from £2 to £5 an acre. The average price of the best fruit land is from £80 to £100 per acre.

At Blairgowrie, in Perthshire, there are some 800 ac. under fruit, most of it being in small holdings. The climate and soil are specially suitable to the growth of raspberries, and from 3 to 5 tons can be grown on 1 ac. One raspberry grower is said to have made a total profit of £492 from 1 ac. of land in nine years. Although the average rent of agricultural land is not more than 30s. an acre, as much as £10 an acre is paid for land leased for fruit growing.

It may be asked why it is that, in view of these and other instances of successful small holdings, the system has not been much more widely extended, and what is the need for any legislative interference in the matter. It must, however, be remembered that the causes which have led to the destruction of so many small

holdings in the past have no connection with the question of their economic success, and that where they have been re-established in recent years it has been mainly on account of the fact that in those districts it has been possible to acquire small plots of land in the open market. The difficulty of obtaining land has been at the root of the question, for there is no doubt of the existence of the demand, and no reason why small holdings should not be successful in many districts where they are at present practically non-existent.

In recent years there has been an increasing tendency among politicians to take whatever measures may be necessary to associate a larger number of persons with the cultivation of land, and to make it possible for any man with the necessary capital and experience to obtain a small holding if he desires to do so. By this means it is hoped to arrest the rural depopulation, and to afford a career in this country to those members of the agricultural population who in the past have too often been driven into the towns or emigrated to the Colonies. The Small Holdings and Allotments Act, 1908, has therefore been passed with the object of facilitating the acquisition of land by County Councils, to be sold or let in small holdings at such a price or rent as will merely recoup the outlay of the Council; and under this Act over 60,000 ac. have already been acquired for some 5000 smallholders.

The question whether a large extension of small holdings will result in a more economic use of the land and in a greater productivity of the soil is one of the first importance. It is a matter on which it is unwise to generalize; but a study of the small holdings which have survived from the past, and of those which have been established in recent years, justifies the belief that small holdings not only result in more intensive cultivation and larger production, but that they also involve a greater amount of labour and the application of a larger amount of capital to the land. Further, there is evidence that where small holdings are common, not only is the rural exodus arrested, but an actual increase of population takes place. In addition, the value of land shows a considerable appreciation, and small men can afford to pay rents double or treble the amount formerly paid by the large farmers. This will have been apparent by the instances mentioned above; but it may be interesting to give an illustration from some small holdings recently established on poor land, and on which no special form of cultivation, such as fruit growing or market gardening, is adopted.

In 1906 a farm of 917 ac. at Burwell, in Cambridgeshire, which had been for two years farmed by the Crown, was cut up into 83 small holdings. 237 ac. are let in quite small holdings to 71 tenants, who use their holdings as adjuncts to their other occupation; and the remaining 680 ac. are let to 12 tenants, all of whom are resident on their holdings and obtain their whole living from them. The following figures have been obtained from these 12 resident tenants. The number of horses they owned increased from 33 in 1906 to 48 in 1909. Cattle increased from 66 to 206, pigs from 122 to 249, and poultry from 267 to 637. The amount expended on purchased feedingstuffs was £753 in 1908 and £1141 in 1909, £777 has been spent on new implements and machinery, and the amount paid for hired labour increased from £846 in 1906 to £1115 in 1909. The turnover of the local co-operative stores has increased by over £1000 in the last two years, 50 new cottages have been built in the village, and it is estimated that the population has increased by at least 200 since the last census. At the rent audit of the small holdings in 1909 every penny of rent due was punctually paid, and there were no arrears.

That there are certain difficulties in the way of the successful creation of small holdings will be denied by no impartial student of the question. Any attempt to transplant on a large scale town dwellers to the country, and to expect them, without previous experience or careful training, to make a living in so technical a profession as agriculture, would be foredoomed to failure, though it is permissible to hope that the offer of land in small holdings will succeed in bringing back to the land some proportion of the rural population who have already drifted into the towns. It is certain, however, that a judicious extension of small holdings will do much to keep in the country a number of men who might otherwise be tempted to leave it, by offering them a career of independence and a prospect of rising above the position of a mere day labourer.

It might have been expected, in view of the higher rents usually paid by smallholders as compared with large farmers, that private landowners would have been more active in cutting up their farms and dividing them into small holdings. In many cases, however, the cost of equipment has been a serious difficulty, at least so far as small farm holdings are concerned which are to be used for growing ordinary agricultural crops, and from which the holders will obtain their whole livelihood. It is often the case that considerable sums have been expended in erecting buildings suitable to a large farm, but which would be rendered useless if the farm were divided into small holdings; while in addition the cost of erecting new houses and buildings for each small holding would result in making the rent which would have to be charged a prohibitive one. Existing buildings can, however, often be adapted and divided for two or more smallholders, and experience shows that the expense of erecting new equipment is often exaggerated. The Commissioners of Woods and Forests have found it possible to equip small holdings of from 30 to 40 ac. with good houses and buildings at a cost which represents an additional rent of from 5*s.* to 6*s.* an acre, and the holdings could have been let many times over at such rents to thoroughly suitable tenants. Moreover, it must be remembered that the principal part of the demand for small holdings at the present time comes from men who have already some work, but who have sufficient spare time to undertake the cultivation of a few acres as an adjunct to their other employment.

To such men a small holding often makes just the difference between bare subsistence and comparative prosperity; and as they have already their houses in the villages, practically no equipment is required for their holdings. Further, in the case of holdings devoted to fruit growing or market gardening, no farm buildings are necessary, such as would be required for an ordinary farm building or one devoted to dairying.

It is commonly supposed that small holdings can only succeed in certain localities where the soil is particularly good and there are special facilities for the profitable marketing of produce. But, as a matter of experience, it has been found that the conditions which make for success are more widespread and various than might at first be imagined. It is no doubt true that, on certain classes of land, large farming is the more economic use of the land; but, even so, that is only the case if the large farmer has sufficient capital at his command. It is notorious that there are many cases where farmers are attempting to farm a large area on wholly insufficient capital, and that in many cases they would be much better off if they concentrated their energies on a smaller acreage.

The most important factor in the success of small holdings is the personal equation. Given the right man, he will succeed in circumstances which might seem hopeless; but at the same time there are other important considerations which should be borne in mind in endeavouring to extend the system of small holdings in any particular locality. The principal favourable conditions are good soil, favourable climate, the proximity of markets, the existence of common rights and surrounding agricultural or industrial conditions affording piece work by which the smallholders may supplement their incomes. It is not at all necessary that all these conditions should be present, for it is found that the existence of any one of them is sufficient to enable a smallholder who knows his business to succeed. For instance, one of the most successful smallholdings colonies is that on the estate of Major Poore at Winterslow, in Wiltshire. There the soil is not good, the climate is not favourable, and the holdings are remote from markets and stations; but there is a considerable amount of winter work in the woods in making sheep cribs and hurdles, and in the summer the smallholders readily obtain work on the large farms. The result has been that a farm of 195 ac., which formerly employed 3 men, has been sold to 49 smallholders, who were enabled to spread payment of the purchase money over a period of fifteen years. Houses have been built on their holdings by 33 of the purchasers. The village was the only one in the neighbourhood at the last census which showed an increase in population, and the presence of the smallholders has afforded a constant supply of extra labour on the large farms at busy times. Winterslow is a good illustration of the fact that it is not necessarily favourable agricultural conditions which determine the success of small holdings.

The question whether small holdings can best be established on a basis of ownership or of tenancy is one on which much difference of opinion exists. The advocates of peasant proprietorship maintain that ownership is the only method which gives sufficient security to the smallholder to ensure that he will expend the maximum amount of labour and capital on the cultivation of his holding, and they point to the experience of the Continent, where the smallholders almost universally own their holdings. The dictum of Arthur Young that the magic of property will turn sand into gold is quoted, and it is contended that under a system of tenancy the smallholder has no security that he will obtain the fruit of his expenditure on the improvement of the land. On the other hand, the system of ownership has many palpable and undeniable disadvantages. It must be remembered that it is the use of the land which the smallholder wants, and that capital employed in the cultivation of land returns a much higher rate of interest than capital employed in its ownership. With the same amount of capital, a man can take as a tenant four or five times the quantity of land he could acquire as an owner. Further, peasant proprietorship offers a direct incentive to mortgaging and subdivision, and it is an actual impediment in the way of a man who desires to rise. Under a system of tenancy the utmost mobility is obtained, and a man can move from one holding to another with the least possible inconvenience and expense. Under the ownership system he must find a purchaser for his holding, and he may only be able to move by sacrificing a considerable part of the capital he has sunk in it.

In a country like Great Britain, where so much of the land has a value in excess of what it is worth as the raw material of agriculture, peasant proprietorship is a system which contains in itself the seeds of decay. There will be a constant temptation to sell the holdings to persons to whom land is more of a luxury than a means of livelihood, and the system offers therefore no hope of permanency. It must also be pointed out that the success of small holdings in Denmark, France, and other Continental countries is due more to their admirable systems of co-operation and agricultural education than to the fact that the smallholders are the owners of their land. The evidence of excessive mortgaging and subdivision is overwhelming. M. Lavergne says of the French peasant that he does not live as well as the English farm labourer, and that he is not so well fed, not so well clothed, and less comfortably lodged. M. Leconteux says that in getting rid of one order of landlords and their rents they have subjected themselves to another though invisible order, the mortgagees and their heavier and more rigid rents. In Holland, subdivision has been carried on to such an extent that scarcely any holdings now remain which are large enough to occupy a man's whole time, and the smallholders have to acquire a number of isolated strips wherever they can be obtained. Mr. E. A. Pratt mentions the case of a Dutch farmer whose holding of 90 ac. consists of no fewer than 78 different parcels of land situated all over the commune. In Denmark, though the smallholders are in theory owners of the land, practically they are saddled by a mortgage

debt of £60,000,000, representing 55 per cent of the value of their farms with buildings, stock, and improvements. It seems clear, therefore, that tenancy, which is moreover the traditional method in British agriculture, is the best basis for an extension of the system of small holdings in this country, provided always that this be associated with adequate security of tenure, with protection against rack-renting, and with a right of ownership to the tenant in improvements executed by his own labour or at his expense.

In conclusion, one word of warning should be uttered. The success of small holdings depends so much on the profitable marketing of the produce, that it will be most unwise to multiply largely the number of smallholders without at the same time building up a system of co-operative distribution. Isolated units who compete with one another are bound to fail, but given a proper system of co-operation there is no reason whatever why small holdings should not be almost indefinitely increased, with the result that a very considerable amount of the poultry, eggs, fruit, and vegetables which now have to be imported from abroad could be produced at home. See also arts. CROFTER LEGISLATION, LAND, LAND TENURE, PEASANT PROPRIETARY, TENANT RIGHT, and the following article. [C.]

Small Holdings Act (England).—The Small Holdings and Allotments Act, 1908 (8 Edw. VII, c. 36), consolidates the provisions of various previous enactments relating to the powers and duties of local authorities in respect of the provision of small holdings and allotments. The Act defines a small holding as 'an agricultural holding which exceeds 1 ac., and either does not exceed 50 ac., or if exceeding 50 ac. is at the date of sale or letting of an annual value for the purposes of income tax not exceeding £50' (sect. 61). County Councils (which include the councils of county boroughs) have the power and, if so required by a scheme under the Act, the duty, by purchase or lease of suitable land, of providing small holdings for persons who desire to buy or lease and will themselves cultivate the land. Every County Council is bound to establish a small holdings and allotments committee, to whom are to stand referred the exercise and performance of the powers and duties of the council under the Act (except the power of raising a rate or borrowing money) (sect. 50). For the purpose of providing small holdings a County Council may purchase or lease land by agreement whether situate within or without their county; and if unable to acquire by agreement suitable land for providing small holdings for persons desiring to rent the same, they may acquire land by compulsion (sect. 7). The power of compulsory acquisition, it is to be noticed, is only exercisable for the purpose of letting land, not for sale of land.

Before the sale or letting of land acquired by them, the County Council may adapt it for small holdings by dividing, fencing, making occupation roads, or works for the provision of drainage or water supply. They may erect buildings or adapt existing buildings for the due occupation of the holding, when such buildings or adaptation cannot be made by the purchaser or tenant (sect. 8). They may sell or let the small holdings to individuals who will themselves cultivate the same, or to persons working on a co-operative system, or, with the consent of the Board of Agriculture and Fisheries, to associations formed for the purpose of creating or promoting the creation of small holdings, and so constituted that the division of profits amongst the members of the association is prohibited or restricted (sect. 9). If the small holding is sold, the purchaser must pay not less than one-fifth of the purchase money on completion; not more than one-fourth may, if the council think fit, be secured by a perpetual rent charge on the property, and the residue is to be secured by a charge on the holding in favour of the council, to be repaid by half-yearly instalments of principal and interest within such term not exceeding fifty years from the date of the sale as may be agreed upon, or by a terminable annuity payable by equal half-yearly instalments (sect. 11). The holding, whether it is sold or let, will for twenty years, and thereafter, in case of sale, so long as any part of the purchase money remains unpaid, be held subject to certain conditions, which provide (amongst other things) that it shall not be divided, assigned, or let without the consent of the County Council, and that it shall be cultivated by the owner or occupier as the case may be, and not used for any purpose other than 'agriculture', which includes horticulture, and the use of land for any purpose of husbandry, inclusive of the keeping or breeding of live stock, poultry, or bees, and the growth of fruit, vegetables, and the like. Not more than one dwelling house may be erected on the holding, and no dwelling house or building shall be used for the sale of intoxicating liquors (sect. 12). In addition to their power of themselves purchasing, a County Council may advance not more than four-fifths of the purchase money to a tenant of an existing small holding to enable him to purchase from his landlord (sect. 19). In order to promote and extend the provision of small holdings, Small Holdings Commissioners are appointed by the Board of Agriculture and Fisheries (sect. 2). If land is hired compulsorily for small holdings by a County Council, the period of compulsory hiring will be from fourteen to thirty-five years (sect. 39). At the expiration of the lease of land hired compulsorily the council has power to renew the tenancy (sect. 44). A council proposing to purchase or hire land compulsorily must obtain an order for that purpose from the Board of Agriculture and Fisheries (sect. 39). The question of compensation payable to those whose land is taken compulsorily is referred to a single arbitrator appointed by the Board (Sched. I, Part 1). No land may be acquired compulsorily which forms part of any park, garden, or pleasure ground, or home farm, or which is woodland not wholly surrounded by or adjacent to land acquired by the council under the Act, or which is the property of a local authority, or has been acquired by any corporation or company for the purpose of a railway, dock, canal, water or other public undertaking, or is the site of an ancient monument or other

object of archæological interest. No holding of 50 ac. or less in extent or any part of such holding may be acquired compulsorily for small holdings or allotments (sect. 41). [A. J. S.]

Smearing Sheep. See art. SHEEP, SMEARING OF.

Smerinthus ocellatus (the Eyed Hawk-moth).—The Eyed Hawk-moth is a beautiful insect measuring from 2¾ in. to over 3½ in. in expanse of wings. The front wings are a rich rose-grey and brown, variegated with pale-olive or chocolate-brown, the outer corner is brown and the tip pale on its upper half; the hind wings are rosy-red, shading off to grey on the margin, with a large bluish eye spot encircling

Eyed Hawk-moth (*Smerinthus ocellatus*)

a black pupil and surrounded by a broad black rim; the thorax is dark in the centre. It is widely distributed over England, and is very common in some places, but is rare in Scotland. The moth is to be found in May, June, and early July. They deposit their large eggs on the leaves of willows, poplars, osiers, apple, sloe, peach, almond, and hops. The larvæ are a beautiful green minutely dotted with white and with seven or eight slanting white bars on each side, bordered above with dark-green; the head has yellowish tints, and the curious tail seen in most hawk-moths is blue, tipped with dull-green or black. They may be found feeding freely on the foliage from June to September. The larval stage lasts about six weeks, and when full grown pupation takes place in the soil, and there the dark-brown pupa remains over the winter and spring. Hand-picking alone is necessary. Owing to their large size the caterpillars are readily seen. Two other allied moths occur in this country, the Poplar Hawk (*Smerinthus populi*) and the Lime Hawk (*S. tiliæ*). [F. V. T.]

Smith, James (1789–1850), of Deanston, agricultural engineer, was the son of a Glasgow merchant, and was born in that city in 1789. He studied at Glasgow University, and at the early age of eighteen he was put in charge of cotton works at Deanston. In 1823 he came into possession of the farm at Deanston, and immediately set to work to experiment on a deep and thorough system of land drainage. He drained the whole farm by parallel trenches 16 to 21 ft. apart, and 2 ft. 6 in. deep, filled up with broken stones to a depth of 1 ft., and above that turf, and then levelled up with earth. He was thus the originator of the parallel system of drainage, which work alone would find him a place in the annals of fame in the agricultural world. But he went further. He invented the subsoil plough. The result of these two inventions on his own farm was the transformation of what had been a wilderness of rushes, furze, and broom into a well-tilled garden. The results of his work he published in 1831, which focused on Deanston widespread attention both from home and abroad. The improvement has been aptly described by a contemporary as 'the most extraordinary agricultural improvement of modern times'. Many other inventions came from his fertile brain, such as one- and two-horse reaping machines, a turn-wrest plough, a web-chain harrow, &c. In 1842 he established himself in London as an agricultural engineer, and was largely employed as a land valuer during the boom in railway construction. He advocated strongly the utilization of town sewage for agricultural purposes, but his efforts were fruitless. At the time of his death he had many more improvements and inventions on hand which others have since perfected and brought out. He died unmarried in 1850 at Kingencleuch, Ayrshire. [A. M.]

Smith, William (1769–1839), geologist and civil engineer, the founder of stratigraphical geology, was born at Churchill, Oxfordshire. He early showed the bent of his mind towards geology, and even when at school was a collector of fossils. This dominating influence no doubt determined his choice of a profession; and his early training, first as an assistant surveyor, and later as a consulting civil engineer, gave him the opportunity to make the observations and gather the data which he was afterwards to use in building up his historic system. He quickly got to the top of his profession as a civil engineer, and for long had a monopoly of the work for drainage and irrigation. Were it only for this, his name would not be handed down to posterity with such reverence. His real lifework, his real ambition all through, was a systematic foundation for the stratigraphy of his country. As early as 1796 he was convinced he had found a key to stratigraphy, namely, identification of the strata by means of their fossil contents. This opened up a great field of research, and it was only in 1815 that, after many failures and disappointments, he was able to publish his map of the strata in England and Wales. Smith's fame was at once assured, and he received the £50 premium from the Society of Arts. He was now in straitened circumstances, but still he devoted more and more of his time to geology. Many of his friends tried to persuade him to publish the records of his many researches, but he seemed to have an antipathy to arranging and publishing his work. Much of his labours, nevertheless, bore fruit at the hands of others, for he was always ready and willing to impart his knowledge verbally to any enquirer. Many honours fell to his share. He was the first recipient of the Wollaston medal from the Council of the Geological Society (1831). In 1832 he was granted a pension of £100 from the Government. Trinity College, Dublin, made him an LL.D. of that university in 1835. Death robbed him of further honours, for in 1839, at the special invitation of the British Association, he was on his way to their Meeting at Birmingham when he caught a chill

and quickly passed away at Northampton. Much brilliant work has been, and still is being, done in this department of geology, but to William Smith, the founder, all honour is due, and none will dispute his position as the father of British geology. [A. M.]

Smoke Damage to Trees.—The smoke from towns and manufacturing centres has an injurious effect on trees in the neighbourhood, giving the leaves a shrivelled appearance and causing 'stag-headedness' in the trees. The smoke cloud not only cuts off direct sunlight from vegetation—and thereby reduces the manufacture of those plant foods which depend on light for their production—but it carries soot, dust, and a variety of injurious gases which result from the combustion of fuels. The effect of black soot and other dusty products on vegetation is comparatively small; it is the invisible gases of the smoke which do the greatest damage. These gaseous vapours will vary with the nature of the fuel employed. Wood smoke and coal smoke from a village or small town without factories is comparatively harmless. The damage reaches its maximum in a neighbourhood of large centres where smelting furnaces, coke ovens, and various kinds of factories and chemical works abound. The greatest havoc is wrought by those invisible gases which contain sulphur and chlorine, because they are widespread, and operate though present only in small quantities. Much injury also results from certain tarlike products (pyridin, phenol, &c.) which are deposited in the dark scum left by smoky fog.

The action of these gases is almost entirely confined to the green foliage of plants. What generally occurs is that the cells of the leaf are injured and an abnormal quantity of water vapour escapes, hence the leaf tissue dries up and loses its green colour. Evergreen trees and shrubs are more injured than deciduous species, because they retain their foliage during winter when more coal is burned, and foggy conditions keep the smoke cloud nearer the earth. Where sulphurous gases are present, Spruce, Scots Pine, and other conifers soon show injury; Cherry, Beech, Lime, and Birch are also sensitive, whereas Ash, Elm, Oak, Poplars, Maples, and London Plane are more resistant. With hydrochloric acid or other gases the order of resistance is somewhat different. The amount of damage can be roughly estimated by the appearance of the trees. Conifers at first show reddish-brown tips on the needles, which have also a sickly dirty-green appearance and fall off prematurely, thus giving the tree a bare appearance. Starvation through loss of foliage is soon evident in thin year-rings in the wood, and this is regarded as a good indication of chronic smoke damage. When the damage is more acute the needles fall off in the first or second year, so that bare twigs and tops appear. The ground vegetation is less affected, but with long-continued acute damage, trees, grasses, and heather (one of the most resistant plants) disappear, leaving a bare, barren soil. The course of damage to deciduous trees is much the same: the leaves are pale and coated with deposit, and withered reddish-brown patches appear between the veins or round the margins. Continuous damage results in death of branches, and so the well-known 'stag-headed' condition is reached. It must not be assumed, however, that all discoloration of foliage is evidence of smoke damage; considerable experience is needed before anyone can attempt to distinguish between discoloration resulting from parasitic fungi and insects, and that produced by smoke.

Agricultural crops are less liable to smoke damage, probably because exposed only for a short period during the least smoky time of the year. As a rule, root crops are least affected, while oats and rye are more resistant than wheat or barley. Clovers, meadow grasses, vetches, and beans are most damaged, especially when young. This different degree of resistance amongst plants has led to an ingenious suggestion for detecting traces of smoke damage; this consists in using 'indicator plants', such as beans, buckwheat, and rhubarb, whose leaves show distinctive spots due to smoke damage.

The direction of the wind in a locality has a great influence on the degree of smoke damage, and this must be considered in establishing new plantations. Smoke is carried farthest on the lee side of the prevailing winds. As a rule, severe damage to trees cannot be traced beyond the first mile or two from the source of the smoke. Lichens on walls and trees are, however, very sensitive to smoke, and their absence has been observed over ten miles from any large town (see LICHENS).

The legal side of smoke damage is extremely complex, because it is difficult to estimate the amount of damage. Two kinds of evidence are generally brought forward—chemical and botanical. The latter is of prime importance, but it is still difficult to prove that any definite kind of damage is directly due to smoke alone. The chemical evidence is more valuable if due precautions are taken in carrying out the tests. Much of the extensive literature on smoke damage owes its origin to legal disputes. A useful summary of a notable lawsuit, the Glencorse, Loganburn, or Shotts case, was given recently (Transactions Roy. Scot. Arboricultural Society, vol. xxii, pp. 15–28 and 221–227). The German forests have also furnished many disputes; a convenient summary of numerous investigations will be found in Rauchbeschädigung, by Haselhoff and Lindau (Leipzig, 1903, 400 pages), which also gives titles of all important works on smoke damage. [W. G. S.]

Smooth-stalked Meadow Grass. See art. MEADOW GRASSES.

Smut, a popular name applied to dark sooty coatings of mould on plants. Within recent times the name has become limited to attacks by the Smut fungi or Ustilagineæ (see art. FUNGI). The best-known Smut diseases are those on the ears of barley, oats, and other cereals; these may be very destructive not merely in producing bad grains, but because the dispersal of the black Smut spores throughout the bulk gives it a faulty colour. (See arts. BARLEY—PARASITIC FUNGI, and OAT—PARASITIC FUNGI.) Grasses are subject to several forms of Smut—some in the ear, others on the leaf or leaf-sheath. Fodder and hay is thus

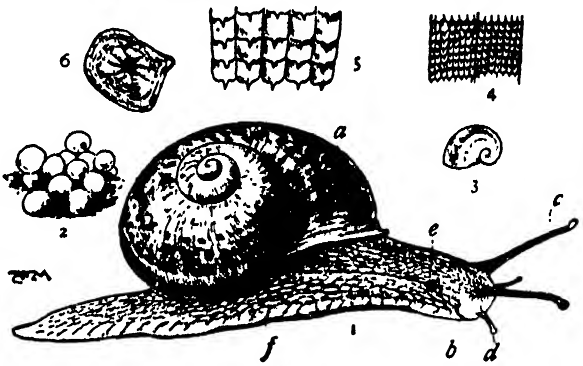
rendered less palatable to stock, and trouble in the throat and nose may result from the dry dusty spores inhaled (see GRASSES—PARASITIC FUNGI). Onion, carnation, violets, and a number of wild plants are also attacked by Smut. The name Stinking Smut or Bunt is used in some districts to indicate a foul-smelling group of the Smut fungi (see TILLETIA). All forms of Smut are difficult to check, but considerable success may be attained by treating the seed before sowing with some fungicide (see BARLEY—PARASITIC FUNGI). [W. G. S.]

Snail Farming.—There is a considerable trade in Paris and other large towns of France in certain species of snails which are suitable for human consumption. Of the species occurring in Britain, only *Helix aspersa* is regarded as edible. The vine-growing districts of Bourgoyne, Champagne, and Poitou, where the soil is calcareous, produce edible snails of the finest flavour. The production of snails for marketing is not, however, systematized. They constitute a menace to the vines and have to be destroyed. In the months of August and September, during the grape harvest, the workers pick up considerable quantities of them for private consumption or for sale. They can then be bought at the rate of about 6*d*. per hundred. Apart from this natural source, it is possible to control the supply of snails by propagating them within a limited space. One method adopted is as follows: The snails are attracted into a large lattice-work box or cage about 1 metre 50 cm. by 1 metre 50 cm. by 2 metres 50 cm., and capable of accommodating over a thousand snails, by means of a few vine shoots, which are caused to penetrate the interstices of the lattice. At the base of the cage are placed a set of drain pipes or metal pipes of a similar size, these being introduced through a small door on one side of the cage. In order to break the fall of any snails which may gain an entrance through the lattice at the top of the cage, straw is placed round the edges of the area covered by the box. Fresh green vegetables are placed above and around these pipes from time to time.

The reproduction goes on in the tiles, from which the young snails may be seen to emerge in spring. When it is wished to have snails for cooking in winter, food of some sort must be provided. A very successful recipe attributed to the Romans consists of wheat meal mixed with water or, preferably, diluted wine. This mixture is put as a coating on the inside of an earthenware tube placed upright on a broad tray. The snails are left in this tube for eight days, after which the flesh will be found to be milky white and, when properly cooked, a very delicate morsel.

But the demand is too limited and the return too small to render profitable the production of snails on a scale to which the term 'snail farming' might be applied. [J. R.]

Snails (Helicidæ).—Snails are all provided with a large external shell into which the mollusc can retire. Like slugs (see art. SLUGS), the snails crawl by means of a large flat muscular foot; they possess a similar mouth, and also two pairs of retractile tentacles. Most form large quantities of slime. The male and female sexual organs are in the same individual, but they do not mature at the same time, and the result is we have cross fertilization accompanied by copulation of two of these hermaphrodite animals. Most snails like damp localities, but some occur in dry, sandy places and on chalk downs. Their food consists of all kinds of vegetation, but some species have decided preference for special kinds of food. Snails live for many years. They usually retire into sheltered places in winter and remain in a dormant condition. Prior to hibernating they may form a hard plate on the foot,



Large Garden Snail (*Helix aspersa*)

1, Mature snail. *a*, Shell; *b*, mouth; *c*, large tentacle; *d*, small tentacle; *e*, genital aperture; *f*, foot. 2. Eggs. 3, Young snail. 4, Part of radula, enlarged. 5, Teeth, further enlarged. 6, Epiphragm.

which, when the mollusc retires into the shell, closes up the aperture very securely. Snails deposit eggs usually in small batches in the soil or under rubbish; the eggs are white shining globular bodies. Young snails are just like the adults, only small, and the shells very thin and often semi-transparent. Those that do most harm in Britain are the following: (1) the Large Garden Snail (*Helix aspersa*), (2) the Wood Snail (*Helix nemoralis*), (3) the Strawberry Snail (*Helix rufescens*), (4) and (5), the Small Banded Snails (*Helix caperata* and *Helix virgata*).

The Large Garden Snail has a brown shell marked with zigzag pale lines. It is one of the largest species and very common, especially in gardens. It lays its eggs in batches of sixty to seventy in the soil. It attacks all garden plants, and is especially fond of sheltering in rockeries and along walls protected by vegetation. These snails winter in masses attached to one another.

The Wood Snail is variable in colour, white, pink, brown, or yellow, with a dark spiral band and dark edge around the shell mouth. It attacks clover, lucerne, &c., especially near woods.

The Strawberry Snail is smaller, seldom more than ½ in. long, and has a more flattened shell, which is dirty grey to rusty brown in colour, with a pale spiral band around the top and

darker transverse streaks. This snail does much damage to strawberries, and attacks many garden plants. It lays eggs between August and November in or on the soil. The Banded Snails are especially prevalent in fields and gardens near the sea, and on downs and hillsides. *Helix virgata* has a white shell with a single purplish-brown band, but, like all others, is very variable. *Helix caperata* differs in being smaller, and in having marked riblike striæ on each whorl. These two latter attack wheat, mustard, clovers, and many other plants.

Snails are preyed upon by many birds—perhaps the thrush is most useful in this respect.

Snails are best destroyed by heavy dressings of soot or application of vaporite around the attacked plants. They cannot be destroyed as easily as slugs owing to their protecting shells, and hand-picking is frequently necessary. [F. V. T.]

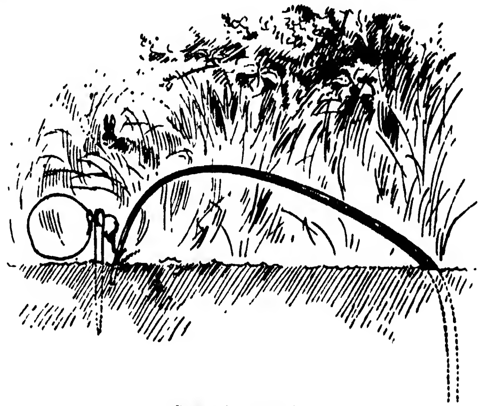
Snakes (Ophidia), an order of reptiles. Among their salient characteristics the following may be noted. The skin is covered with scales, and the horny layer of the epidermis outside of these is periodically shed in a coherent 'slough'; there are no traces of fore limbs or pectoral girdles, and only a few snakes show minute vestiges of a pelvic girdle and hind limbs; there are numerous vertebræ, sometimes nearly three hundred, and all, except the first and those of the short tail, bear ribs which are fastened ventrally to large transverse scales and are used in locomotion; the mouth is very expansible, in adaptation to swallowing large prey, thus many of the skull bones are movable, and the two halves of the lower jaw are united in front by elastic ligament; the bifid, mobile, retractile tongue is an organ of touch; the eyes are not movable and there are no movable eyelids; there is no external ear-opening, nor drum, but snakes hear well, and the sense of smell is often well developed; in poisonous snakes one of the salivary glands is specialized as a poison gland, and the venom trickles down a grooved or channelled tooth; most snakes are oviparous, but vipers and aquatic species and some others are viviparous. Snakes are divided into numerous families, such as the archaic burrowing Typhlopidæ, the usually large Boidæ, the numerous Colubridæ, the deadly Viperidæ. There are only three British species—the poisonous adder or viper (*Vipera berus*), the non-poisonous grass snake (*Tropidonotus natrix*), and the rare non-poisonous smooth snake (*Coronella lævis*).

The practical importance of snakes is in the main connected with the poisonous bite of many of them. In opening the jaws and erecting the fangs, the poison glands are compressed and the venomous secretion is injected down the tooth into the deepest part of the wound. Several mammals are immune—the pig, the hedgehog, the mungoose, and perhaps also a kind of dormouse known as the lerot. Similarly, the secretary bird, the stork, and the honey buzzard are immune. Though venomous snakes are dangerous to man and to his non-immune stock, it must be carefully noted that snake-killing may be carried too far, for they destroy large numbers of rats, mice, and other vermin. Some of the large boas and pythons, which are non-poisonous, and kill their prey by crushing it, levy toll on kids, lambs, poultry, and the like. A very interesting African snake, *Dasypeltis scabra*, feeds chiefly on eggs. Pigs deal effectively with the deadly rattlesnake of the United States, and sheep are said to jump deftly with their fore feet on the European adder. [J. A. T.]

Snakeweed, also called Easter Giant and Patience Dock and Bistort, is a perennial herb belonging to the nat. ord. Polygonaceæ. See BISTORT.

Snapdragon, the popular name for Antirrhinum, a genus of plants which belongs to the nat. ord. Scrophulariaceæ. See ANTIRRHINUM.

Snares and Snaring.—The name snare is usually applied to a contrivance for capturing



Snare for Rabbit

animals that is simpler in construction than the steel gin and cage trap, which are more correctly described as traps. The snaring of animals is a more ancient way of capturing them than trapping; and although at the present day it has been to a great extent superseded by trapping, yet snares are still widely used in the country, and often quite as effectively as the more modern trap. The usual mode of procedure is very simple. A supple twig is driven into the ground; the upper end is bent over and has attached to it a wire which is twisted into the form of a loop so as to form a running noose. The apparatus is set up in such a position that the open noose hangs exactly over a 'run' of hares or rabbits. As the animal comes unsuspiciously along it runs its head into the noose, which closes tightly round its neck; and the more violent the animal's efforts to escape the more firmly does the wire clasp its neck. Many varieties of this simple contrivance are employed. When it is desired to catch rabbits in a wood, the wire noose is often attached to a young tree, which is bent right over, so that its top comes close to the ground. The wire is fastened very insecurely to the ground, so that at the least disturbance the fastening gives way, and the tree, swinging upwards by virtue of its elasticity to its natural position, suspends the snare in mid-air. Animals which are caught in this variety of snare are thus literally hanged.

Snares were in general use in former times for the purpose of catching moles. The ordinary wire noose and bent stick were fixed in a sort of wooden tunnel, which was set inside the animal's burrow; so that when it came along, the little creature set free the fastening and was drawn up and strangled. This device has now been supplanted by the modern mole-trap. For the recent 'stop-ring' wire noose, see art. TRAPS FOR VERMIN. A general advantage possessed by snares over steel traps is that they inflict far less pain on the captive animal. They are liable, however, to the objection that the animal is not so securely held, and is more liable to make its escape after it has been caught.

For capturing such birds as owls, snares with delicate horse-hair nooses are often employed, these being set in position over the holes in which the birds are known to be sitting, so that on their exit they are caught.

Nets were at one time very extensively employed for catching birds such as partridges or pheasants. Their manipulation is usually a very simple matter, nothing more being required than to set the nets, and then slowly drive the birds by making them run in advance into the nets, or else leave them to find their way in of their own accord. The method is little used except by poachers. The legitimate form of netting birds with clap-nets is dealt with in the article BIRD-CATCHING. [H. S. R. E.]

Snipe.—There are three species of snipe found in Great Britain, of which the Common Snipe (*Gallinago cœlestis*) is one of the commonest of British wading birds, and is found in all parts of the United Kingdom. The general colour of the back is mottled black, with two longitudinal bands of sandy buff. The rump and upper tail coverts are tawny rufous, the throat and chest sandy brown, mottled with blackish spots and bars, and the breast and abdomen are pure-white. The sexes are alike in colour, and the total length of the bird is about 10 in. The Common Snipe may be distinguished from its ally the Great Snipe by the absence of white tips to its wing coverts, and by the possession of only fourteen, instead of sixteen, tail feathers. The snipe frequents swampy and marshy districts either along the sea coasts or inland, but it is a difficult bird to see while on the ground, and does not generally rise unless flushed by the sportsman. Even then it is not easy to hit, for its flight is extremely swift, and it twists and turns in a zigzag manner until it has reached a safe distance. At night, however, the birds expose themselves more readily. The snipe is not usually a gregarious species; for the most part the birds hunt their food separately.

One of the most curious characteristics of the snipe is the 'drumming' of the males during the breeding season, a noise quite distinct from the ordinary call of the bird. The manner in which this drumming sound is produced was for a long time a subject of much discussion. It was known that it was not produced vocally; and while some naturalists asserted that it was caused by the rapid vibration of the wings, others alleged that it was due to the air rushing swiftly through the tail feathers. Recent researches appear to indicate that the latter is the true theory. Certain of the snipe's tail feathers are curiously formed, and when tied to a stick and swung rapidly through the air, give rise to the drumming sound. The sound is only given out by the bird when on the wing, usually high in the air, and only when descending. A similar sound is produced by lapwings, also only when descending; but in their case it is obviously caused by the wings. The snipe breeds in all parts of the British Isles, and lays four eggs. Its numbers are augmented every autumn by the immigration of foreign birds.

The Great Snipe (*Gallinago major*) is a not infrequent visitor to these islands. It occurs mostly on the east and south coasts in early autumn. The Jack Snipe (*Gallinago gallinula*), which is mottled brown and black above and white below, and is decidedly smaller than the Common Snipe, is a winter visitor to this country, but does not breed here. [H. S. R. E.]

Snow.—When dust particles in the atmosphere are being attracted together below freezing-point snow is formed. The size of flakes varies from about 1 in. down to $\frac{1}{10}$ in. in diameter. Fresh-fallen snow is very light, as the particles are not dense, and 1 ft. of it gives only 1 in. of water when melted; but its density increases when it lies, partly by compression, due to its own weight, greatly by thawing and re-freezing. Snow in the shade on a bright day at noon is 7 deg. F. colder than the air that floats upon it, whereas a black surface at the same is only 4 deg. colder. This difference diminishes as the sun gets lower, and at night both radiate almost equally well. The temperature of lands when covered with snow must be much lower than when free from it. Besides being a bad absorber of heat from the sky, snow is also a very poor conductor of heat. The snow-line is the height above which snow perpetually lies. In Greenland it is 2350 ft., in the Himalayas 19,500 ft. The protection afforded by snow is of great importance in the economy of Nature. [J. G. M'P.]

Snow Damage to Trees.—Snow only damages trees if falling in large quantities, by causing their branches to be bent down or broken off. Of our common coniferous woodland trees the brittle Scots Pine is most liable to damage from snowbreak; while among broad-leaved trees, Beech, Alder, Crack Willow, and Robinia have the most brittle branches. In Central Europe, where snow falls heavily and lies long, young Spruce, Oak, and Beech woods are sometimes laid by snow pressure, but this is seldom likely to occur in Britain. Damage from snowbreak may occur anywhere or all over in Scots Pine woods; but in other kinds of tree crops it is chiefly confined to the edges of compartments, or to small patches here and there. Heavy snow can be shaken off young ornamental trees in parks, avenues, or small plantations, by shaking the poles or tapping them with a padded mallet; but in woodlands this is impracticable, and the only way of preventing damage is to tend the woods carefully, especially with regard to moderate thinning. [J. N.]

Snowdrop, species of Galanthus, a genus of Amaryllideæ, natives of Europe and Asia Minor. They are great favourites by reason of their beauty, and the early season at which they appear. Bulbs of the common kinds are inexpensive, and should be planted in large quantities for naturalizing in short grass in partial shade, as by the sides of carriage drives. When once planted they will take care of themselves and usually increase. *G. nivalis*, the Common Snowdrop, of which there is a double variety, is found in some parts of England. *G. Imperati* is a very large form of *nivalis*. In addition to planting outdoors, *G. Elwesei*, Asia Minor, Giant Snowdrop, is an excellent subject for flowering in pans in a cool greenhouse, but it is not everywhere easy of cultivation. *G. plicatus*, Crimea, is somewhat similar to *G. nivalis*, but the flowers are more often of a greenish hue. There are also some autumnal-flowering Snowdrops, which are natives of the mountains of Greece; the so-called Yellow Snowdrops, which have rich-yellow ovaries, and yellowish flower-stalks; and Green Snowdrops, whose outer petals are more or less green. [W. W.]

Snow Flies. See ALEYRODES.

Snow Ploughs usually employed are simple constructions of wood, sometimes shod with iron, made heavy to keep the edges on the ground. Stout baulks of timber are braced together to form an angle at the centre, so that as the plough is drawn forward the snow is shoved aside as by an ordinary double-breast plough. Sometimes a steerage handle is attached, but the draught of the horses practically decides its course. Where the snow has congealed below, a series of steel studs set along the wings of the plough are sometimes employed; but need for these is exceptional. [W. J. M.]

Soda Salts are extensively used in the arts and industries. Some occur naturally, whilst others are prepared by chemical methods. Among the principal naturally occurring salts may be mentioned common salt or sodium chloride, and nitrate of soda or Chile saltpetre. The former occurs as the mineral rock salt in various parts of the world (see SALT). The latter is found in large quantities in Chile (see NITRATE OF SODA). Until latterly, the Chile deposits formed practically the sole source of supply of nitrate. *Sodium carbonate*, better known as 'washing soda' or 'soda', was first imported from Spain under the name of barilla, the ash of the seaweed *Salsola Soda*. The ash contained about one-quarter of its weight of soda. At the present time it is manufactured in enormous quantities from common salt by chemical methods. The crystals of this salt contain water of crystallization, which is partly lost when the salt is exposed, causing the crystal to crumble. It is used for domestic and medicinal purposes; in the preparation of glass, caustic soda, and many other substances. The acid carbonate is an important constituent of many beverages. *Sodium sulphate*, or Glauber salt, occurs in the native state in large quantities in Germany. It is valuable because of its medicinal properties. *Borax*, sodium pyroborate, is another important compound of soda. It occurs naturally in some lakes in Tibet, and as the mineral tincal. It is now prepared in large quantities by heating sodium carbonate and boracic acid together. It possesses valuable antiseptic properties, and is largely used as a preservative. *Sodium bromide* and *hyposulphite* are indispensable in photography. *Sodium arsenite* is a constituent of some sheep dips, &c. Sodium salts are found in soils, the ash of all plants, and in the juices of the body. [R. A. B.]

Soft Brome Grass, a common hairy annual or biennial weed grass found by roadsides and on waste places. See BROME GRASSES.

Soft Cheese.—A soft cheese is a cheese which is made without pressure. The curd is produced very much in the same way as the curd which is required for a pressed cheese, but the whey is removed in a different way. The curd is not cut, as is the case in the manufacture of pressed cheese, in which it is divided in so many instances into small cubes, but is usually removed in large slices into the moulds in which the cheese is to take its form—and which are sometimes perforated to assist the whey in escaping—and allowed to drain, as they do perfectly when the conditions are correct. The chief of these conditions is the temperature, which should not be too high to induce the whey to escape too extensively, or too low, and so to prevent the escape of a sufficient quantity. A soft cheese contains a larger quantity of whey than a pressed cheese, and is of necessity small in size. In almost all varieties the ripening process is conducted from the outside by the aid of fungi which grow upon the surface, and which play an important part in the removal of the acid. As a rule, a soft cheese seldom exceeds an inch in thickness.

There are certain qualities which are common to all varieties of soft cheese, and especially to those which are made from full milk. As the mycelium of the fungus penetrates into the curd and neutralizes the acid, so the bacteria are able to commence their work of converting the insoluble curd into the soluble cheese, and to communicate its flavour. Thus there is a close resemblance between the Brie, the Camembert, the Coulommiers, the Bondon, and the Gournay. The first mould to appear is white, which, in the case of a cheese which is not turned, grows until it becomes very like a velvet pile. This is followed by a blue mould, and in the case of one or two varieties, the Brie included—but only in the hands of certain makers—with *boutons* of vermilion mould; in each case the mould is crushed by daily turning, and in consequence the appearance of the crust of the cheese is a dirty grey, which is by no means inviting except to those who know what lies beneath. Where soft cheese becomes overripe the crust is apt to burst, and the curd, which has become almost fluid, runs out. It should be needless to say that in this condition the cheese has lost its normal value, although among the workmen of the Continent cheese in this condition is very often preferred, owing to its more pungent flavour. The following figures may prove useful to those who are interested in soft-cheese manufacture:—

Name of Variety.	Temperature of Renneting.	Time of Coagulation.	Water.	Analysis.		Remarks.
				Fat.	Casein, &c.	
Brie	82°–86° F.	2–4 hr.	50·35	26·12	17·18	Ripening stages, 61°, 65°, 50° F.
Camembert ...	86° F.	2 hr.	40·3	29·9	29·8	11 to 12 oz. in weight, 4½ lb. milk per cheese.
Pont l'Évêque ...	88° F.	15 m.	—	—	—	1 gal. milk per cheese: ripening stages, 63°, 56°, 56° F.
Neufchâtel ...	90° F.	24 hr.	44·47	33·70	14·60	1 lb. milk per cheese.
Géromé	90° F.	30 m.	—	—	—	12 lb. milk per 1 lb. cheese.
Mont d'Or ...	85° F.	30 m.	—	—	—	——
Gervais	65° F.	8–12 hr.	52·94	29·75	11·80	Cream is mixed with milk.
Livarot	95° F.	1½ hr.	—	—	—	——

The following is a list of the principal varieties of soft cheese made in different countries:—

England: York, Godmanchester, New Forest, Slipcote.

France: Brie, Camembert, Coulommiers, Neufchâtel, Bondon, Livarot, Géromé, Mont d'Or, Pont l'Évêque, Void, Gournay.

Germany and Belgium: Limbourg.

Italy: Stracchino. [J. Lo.]

Soft Soap is the potash salt of some fatty acids, and is prepared principally from whale and seal oil by heating with caustic potash. Soft soap is used extensively as a constituent of washes employed for eradicating insect pests. The soft soap is dissolved in water and mixed with various destructive substances the nature of which depends upon the kind of pest. The following is a list of some of the substances used: mineral oils, quassia, sulphur, gas lime, lime water, tobacco, bitter aloes, &c. The object of using soft soap is to make the wash adhere more firmly to the tree or insect to which it is applied. Some leaves have a very smooth surface, and the skins of some insects would allow the wash to run off readily unless it contained some substance of a sticky nature. Another use of the soft soap is to block up the breathing pores of the insect. This is best done by applying a concentrated solution of the soap. See arts. INSECTICIDES; PARAFFIN, USE OF IN AGRICULTURE; QUASSIA. [R. A. R.]

Softwoods are those which, in contradistinction to hardwoods (see HARDWOODS), offer little resistance to the penetration of another body (*e.g.* nails, screws, axes, &c.) into their substance. Some of the softwoods are, however, among the most difficult to saw (*e.g.* Willow and Poplar), owing to the strong resistance offered to the teeth of the saw tearing their fibres apart. The softwoods commonly grown in British woodlands are, among broad-leaved trees, Poplars, Willows, Lime, Horse-chestnut, Alder, and Birch (though Birch is sometimes classed as a hardwood); and though none of the conifers have a really hard wood, the typically soft kinds are Sequoia, Cryptomeria, Weymouth Pine, Spruce, Silver Fir, Hemlock, and *Thuja gigantea*, while those having a distinctly coloured heartwood (see HEARTWOOD), such as Larch, Pines, and Douglas Fir, are somewhat harder. As a rule, most kinds of wood having a low specific gravity (below 0·65 when seasoned) are soft, although in conifers hardness increases with the degree of resinousness, and green wood is usually softer than seasoned. Coniferous timber is the easiest or softest of all to saw, though Larch is harder than Pines and other kinds of Firs; while among broad-leaved trees the softwoods Poplars, Willows, Lime, and Birch are harder to convert than Alder, Beech, Maple, Sycamore, or Oak, owing to their soft tough fibres and the more clogging action of the woolly sawdust. [J. N.]

Soil.—In this article an outline of the general properties of soil, of their relationships one to the other, and of their bearing on fertility is given. No attempt is made to go into full details; this has been done in other articles, to which the reader is referred. The subjects are taken in the following order:—

1. The substances present in the soil.
2. The living organisms of the soil.
3. The changes taking place.
4. The soil in its relation to the plant.
5. Inherent fertility and condition.
6. Soil exhaustion or deterioration.
7. Soil amelioration.

The Substances Present in the Soil

§ 1. The great bulk of what is now the soil was at some remote period solid rock, and before that again had been a molten mass. By the various agencies which have been described elsewhere (see SOIL, GEOLOGY OF), the rock was splintered up into fragments and subjected to chemical actions whereby new materials were formed. Many subsequent changes took place; often the particles were washed down river courses into lakes or seas and lay under water for long ages, mixed up with the remains of decomposing plants and animals which largely disappeared but always left some residue. In some cases the residue—shells and so on—formed a considerable part of the deposit, and always it added something. The deposits increased in thickness and consolidated under the pressure of the superincumbent layers; usually some substance was present which acted as cement. Other changes in the earth's surface caused the sea to disappear and the bottom to become dry land or solid rock. Once again the process of breaking down set in; the cementing material dissolved, the particles were carried away by water and went through the same process as before. This action of water, the 'denudation' of the geologist, is always going on. Valleys are scooped out and the smaller soil particles wash downhill into them. River courses

are perpetually changing, and making the great alluvial flats.

§ 2. The important facts for us to bear in mind are: (1) the particles of the soil have been formed in two ways from the original rock—(*a*) by disintegration, in which case they retain the chemical characteristics of the rock; (*b*) by decomposition, when their properties are different; (2) the particles are very old and have been subjected for ages to the action of water, carbonic acid, &c.; (3) the plant and animal matter, in decomposing, leaves behind a residue of mineral and organic matter intermingled with the soil. Only the most resistant of the original rock particles have survived, and these do not suffer any appreciable change in the course of a few years; for agricultural purposes indeed they may be regarded as unchangeable.

§ 3. The original rock particles are complex compounds containing iron, aluminium, silicon, calcium, magnesium, potassium, sodium, and others. As they retain the properties of the original minerals, they can be identified, if they are large enough, by the methods of mineralogist analysis. It is from the physical rather than the chemical point of view that these particles are important; their size and not their composition counts. The coarse, gritty particles vary in mean diameter from 3 to 0·2 mm., and are mainly silica, whilst the finest clay particles are less than ·002 mm. in diameter, and contain larger amounts of iron and aluminium oxides. The composition of the several fractions of the Rothamsted soil is as in table on next column. When a particle is broken up, the separate pieces have a greater total surface than the original particle, and the further the breaking up has gone the greater is the increase in surface. The finest constituents of the soil therefore present a much larger total surface than an equal weight

Fraction.	Silica (SiO_2).	Oxide of Iron (Fe_2O_3).	Alumina (Al_2O_3).
Fine sand (0·2 to ·04 mm.) ...	94·6	1·1	3·4
Silt (·04 to ·01 mm.)	92·0	1·2	6·2
[1] Fine silt (·01 to ·005 mm.) ...	88·3	1·8	8·5
Fraction between ·005 and ·002 mm.	61·7	7·0	23·4
Clay (below ·002 mm.)... ...	45·9	12·2	30·9

of the coarser material. Clay stands out in marked contrast from the other soil constituents. It is coherent, and resists the movement of the tillage implements; it is therefore called heavy, although in reality it is somewhat lighter than sand. It will remain suspended for long periods in water. Lime, alum, and other salts, acids, &c., cause the particles to aggregate or flocculate, and temporarily to behave like coarser ones; on the other hand, ammonia and alkalis, such as soda, potash, or their carbonates, cause the particles to deflocculate and assume their most sticky and tenacious form. Clay, or rather some of its constituents, withdraws organic matter and various mineral substances from their solutions (see art. CLAY). The silt is valuable to form the body of the soil, since it possesses many desirable characteristics in relation to water and temperature. Sand keeps the soil open and workable. There is no sharp distinction between these fractions; they shade off one into the other, and are distinguished only for the sake of convenience. It is therefore quite wrong to say, as is sometimes done, that soil is a mixture of two earths, sand and clay.

The specific gravity of the soil constituents in the state of separate grains is about 2·5, but in the porous mass present in the soil it is much less because of the air present. Some of the weight relationships are as follows:—

	Water.	Humus.	Clay.	Quartz.	Felspar.	'Heavy' Arable Land, Rothamsted.		'Light' Arable Land, Woburn.		Old Pasture Soil, Rothamsted.	
						Top 9 in.	Fourth 9 in	Top 9 in	Fourth 9 in.	Top 9 in.	Fourth 9 in.
True specific gravity (as separate particles) ...	1·00	1·2 to 1·5	2·50	2·62	2·5 to 2·8	—	—	—	—	—	—
Apparent specific gravity (as porous mass) ...	—	·335	1·01	1·45	—	1·434	1·627	1·550	1·715	1·144	1·642
Weight per cubic foot in natural state, lbs. ...	62·32	20·9	63·0	90·3	—	89·4	101·4	96·6	106·9	71·3	102·3

The soil at the fourth depth is heavier and more compact than at the surface, but the consolidation does not increase at greater depths. It will be observed that the 'light' sandy soil at Woburn is really heavier than the 'heavy' loam at Rothamsted.

The decomposition products of the original rock particles are of more chemical interest, inasmuch as they enter into reaction with ammonium or potassium salts added as manure (see § 19).

§ 4. Among the minerals of organic origin calcium carbonate is by far the most abundant, especially in the great chalk and limestone deposits, where it formed, in past ages, the shells and other parts of animals. It occurs in many but not in all soils, and has the distinction of being the only common soil constituent that is sometimes totally absent.

Equally widespread, but less abundant, is calcium phosphate, part of which also arises from the residues of a past life. But there are other mineral phosphorus compounds, commonly regarded as phosphates, that are not extracted even by strong acids and are clearly of mineral origin. No sharp classification of soil phosphates

[1] It is now usual in Great Britain to regard fine silt as lying between ·01 and ·002 mm.

is possible: some are soluble even in the solution of carbonic acid occurring in the soil, others are highly insoluble: between these two extremes lie other compounds, so that any particular solvent will go on indefinitely extracting phosphoric acid from the soil.

§ 5. The organic matter of the soil, *i.e.* the part which can be burned away, forms about 3 to 6 per cent of arable soils, 5 to 10 per cent of pasture soils, and a considerably larger proportion of peat soils. It has been only incompletely studied. It arises from the activity of the living plants or organisms that find their habitation in the soil, and has been accumulating and changing ever since the soil began to be formed. The oldest portion dates back to the time when the soil was deposited, and can be found unmixed with recent material in soil samples taken some depth below the surface; the newest part arises from the roots or leaves and stems of plants recently drawn into the soil by earthworms, &c. Generally we may say that the oldest organic matter is very resistant, having already undergone most of the change of which it is susceptible, while the recent organic matter is readily decomposed. The decomposition products play an important part in the soil. Among them is the black body called humus (see art. HUMUS), which gives to soil those properties associated with mould, and is in part responsible for the great distinction between a mere sand heap and a soil. Three of its important properties are: (1) it increases the water-holding capacity of the soil; (2) it facilitates the production of tilth; (3) it absorbs the dissolved organic matter from solutions, a property which it shares with clay, and which accounts for the purity of many deep well waters.

There are probably a number of nitrogen compounds in the soil, but only two have been examined in their relationship to plant growth —ammonia and nitrates. Of ammonia only traces are ever found under normal conditions. Nitrates occur in very varying amounts: arable soils will commonly contain from 3 to 12 parts of nitrogen in this combination in every million parts of soil—the lower amount in wet weather or when a full crop is on the ground; the higher in warm, dry weather when the ground is not densely covered with crop (see NITROGEN COMPOUNDS IN SOIL).

§ 6. The soil is, in our regions, always moist, but the water is not pure. It is a solution containing a certain amount of every soluble soil constituent — carbonates, nitrates, sulphates, chlorides and silicates of sodium, calcium, magnesium, potassium, and so on. It is more or less saturated with carbonic acid, which dissolves calcium carbonate and other mineral matter, and it plays a highly important part in plant nutrition. Its composition is not readily investigated, because the clay and some of the organic matter, *e.g.* the humus, react with it and withdraw sundry constituents. Whitney (Bureau of Soils, U.S. Department of Agriculture, Bulletins 22 and 23) supposes that this solution is of the same strength in all soils, and therefore that all soils contain the same amount of plant food, but his theory is not commonly accepted (see FERTILITY). Russian investigations are recorded in the Jahresbericht über Agrikulturchemie (1906, p. 51).

§ 7. We may now sum up our account of the constituents of the soil. It is largely composed of fragments of rock varying in size from 3 mm. downwards. These were detached ages ago, and have ever since been subjected to the action of water, air, &c., so that they may be regarded as unalterable in agricultural time. But in geological time some of them are decomposed; the resulting products also occur in the soil and are distinguished by being more reactive; thus they react with potash salts, ammonium salts, &c., and also yield some alkaline material to water. All through the existence of the soil it has perpetually been mingled with living or dead plants, animals, and minute organisms which have contributed organic matter, but have also effected decomposition of some of the organic matter already present. This endless cycle is still going on. The soil thus contains combined nitrogen and certain minerals like calcium carbonate, calcium phosphate, &c., which at various times have formed part of the living organisms and may do so again. It also contains the stable organic residues marking the limit beyond which decomposition has not gone, and representing the organic matter added in bygone ages; these are the end products of the change. Products representing the initial stages arise from organic matter recently added to the soil, and include humus and the nitrates. Between these two stages are doubtless many others, of which little or nothing is known.

Bathing the soil particles is a solution containing some of every soluble substance in the soil. Its principal constituent is carbonic acid if calcium carbonate is absent, or calcium bicarbonate if it is present. In addition it contains nitrates, salts of calcium, magnesium, &c., and plays a great part in the nutrition of the plant. The differences between the surface and subsoil are set out in art. SUBSOIL, where also are described the attempts to utilize the subsoil as plant food in the Lois Weedon system.

§ 8. We must not look upon the soil as a mere inert mass of material. Prior to the days when agricultural chemistry was first studied, the soil was regarded as being endowed in some mysterious way with life—a survival of the ancient Greek idea that the Earth was the common mother of all. Even so late a chemical writer as Boerhaave in 1727 speaks of a vegetable as 'a body generated of the earth, or of something arising of the earth'; and of the soil, itself as 'in some measure organical', containing pores 'something analogous to vessels by which juices may be convey'd, prepared, digested, circulated, and at length excern'd, and thrown off into the roots of plants'. But more exact ideas were introduced when agricultural chemistry arose at the end of the 18th century. The early agricultural chemists make no reference to a living soil, but regard it simply as a mass of dead mineral and organic matter. The mineral matter was decomposed by chemical agencies under the influence of air and water; the organic matter decomposed spontaneously,

giving rise to humus, carbonic acid, and simple nitrogen compounds which served to nourish the plant. These are the ideas developed by Boussingault as late as 1851 in the second edition of his Economie Rurale; and they were in complete harmony with the theory of putrefaction and fermentation advanced by Liebig, which supposed these changes were purely chemical. Even when Pasteur had demonstrated the presence of disease and other organisms, and Boussingault in 1858 (Agronomie, vol. i, p. 301) had recognized the existence of a 'mycodermic vegetation' not always visible to the naked eye, the progress of which must be followed by the aid of the microscope, there was no suspicion that this 'vegetation' was in any way concerned in soil fertility. Later on, the true nature of putrefaction was cleared up: the minute organisms found in enormous numbers in decaying organic matter, and which the older writers thought were engendered by the decaying organic matter, were shown to be the cause of putrefaction and to arise from some germ previously present. It seems strange to us to find even in 1877 Tyndall writing a long paper controverting the idea of spontaneous generation of what we now know are the putrefaction organisms. In 1878 Schloesing and Muntz showed that ammonia is converted in the soil to nitrates by bacteria, and this discovery marks the beginning of soil bacteriology. The stages in the decomposition of organic matter whereby plant food is produced by bacterial agency were clearly set out by Warington in 1883. A notable advance was made in 1885 by Berthelot, who showed that atmospheric nitrogen is fixed in soil by micro-organisms. In the following year Hellriegel and Wilfarth showed that leguminous plants were dependent on certain bacteria for their nitrogen supply. Details of much of the recent work will be found elsewhere under the proper headings (NITRIFICATION, DENITRIFICATION, NITROGEN FIXATION, &c.).

The Living Organisms of the Soil

§ 9. The top 6 in. of the soil is tenanted by a teeming population of the most varied kind, from large earthworms down to minute organisms only visible under a powerful microscope. Several hundred millions may be present in each ounce of soil. They show great diversity in their food, their mode of life, and the way they are influenced by external conditions. Some live on dead organic matter, others attack plants, others again devour living organisms. All are competing in the struggle for existence, multiplying with enormous rapidity whenever the conditions are favourable, disappearing equally quickly when they are unfavourable, or taking on a curious state of suspended animation, in which they may lie dormant for long periods and yet revive as soon as the conditions are once more suitable. In the struggle no one species exterminates the rest; instead, the different forms seem to settle down to a rough kind of equilibrium, each being hampered by others, but all surviving in some degree; the equilibrium does not vary very much so long as the soil conditions remain fairly constant.

§ 10. We should get a very incomplete picture of the soil if we confined our attention to those organisms which are directly beneficial to the plant. It is true that the plant gains by the presence of certain of the organisms, and equally true that some of the organisms benefit by the presence of the plant. But the organisms of the soil are living their own lives, and their immediate functions are to feed, to grow, and to multiply. However, as it is necessary to set some limits to the subject, we shall not attempt the complete picture.

§ 11. EARTHWORMS.—Of all the larger organisms none are more important than earthworms. They feed on vegetable matter, dead leaves, stems, &c., and do a good deal of cultivation as they work their way through the soil, passing quantities of it into their bodies, and throwing it out on the surface in the form of casts. Into the burrows they draw vegetable matter, which thus becomes distributed in the soil. The burrows also aerate and drain the soil, while the casts act as a mulch.

INSECTS, CENTIPEDES, &c.—Some of these, like worms, live on dead vegetable matter, others on living animal matter, on slugs, snails, grubs, &c. —*e.g.* centipedes (Chilopoda), ground beetles (Carabidæ); while others again feed on living plants—*e.g.* some millipedes (Julidæ), wireworms, leather-jackets (Tipula). Probably all have in some degree the same kind of cultivating effect as earthworms; but those attacking plants do more harm than good in arable land, and are therefore regarded as pests. The others, however, are on the whole beneficial.

NEMATODES.—Eelworms (Anguillulidæ), although microscopic in size, are similar in structure to the other worms. Some are parasitic on plants, attacking corn, clover, sugar beets, &c.; others are saprophytic, and live on decaying organic matter; while others again are parasitic on animals—lung worms of sheep. It is not known what action they have in the soil.

§ 12. ALGÆ.—When the surface of the soil is kept damp and undisturbed, a green growth of algæ will sometimes develop. They live like the higher plants, assimilating carbonic acid from the air and taking plant food from the soil; they therefore compete with plants for food. It is not, however, known to what extent they are operative in ordinary cultivated soils.

§ 13. PROTOZOA.—These have not yet been studied in any detail from the soil point of view, but several of them, *e.g.* various Amœbæ, certain Monads, and *Colpoda cucullus*, have been found in soils, and it is certain that others are present. The chief food of those found so far consists of smaller organisms and bacteria; they are in consequence detrimental, in that they keep down the useful bacteria which prepare plant food.

§ 14. MOULDS AND FUNGI.—Moulds prefer an acid medium, and are said to predominate over bacteria in acid soils, but proof is lacking, as no way of counting them is known. Two classes may be distinguished: (*a*) those feeding on liv-

ing plants—the disease fungi, such as *Phytophthora infestans*, which causes the potato disease, or *Plasmodiophora brassicæ*, which causes finger-and-toe in turnips; *mildews*, &c.; (*b*) those feeding on dead organic matter—Penicillium and others. Moulds require air. The decomposition they effect does not appear to be as beneficial to plants as that brought about by bacteria. Bacteria reduce complex nitrogen compounds to simple forms useful as plant food. Moulds, on the other hand, absorb some of the simple nitrogen compounds into their own substance, and to this extent decrease the amount of plant food in the soil. A familiar illustration is furnished by dung, which is known to lose in value when attacked by mould, often spoken of as 'fire-fang'.

§ 15. Bacteria.—A remarkable variety of bacteria is found in the soil. The general result of their work is to oxidize organic matter and produce plant food and humus. They also produce carbonic acid, which attacks and dissolves some of the mineral substances in the soil. They have enormous power of reproduction, but are kept in check both by the adverse conditions and by the activity of protozoa and similar organisms. Calcium carbonate, phosphates, and other mineral salts are necessary for all bacteria, and nitrogen compounds and organic matter for most of them; they also require favourable conditions of water, air, and temperature. The numbers present are sometimes enormous; an ounce of the Rothamsted soil has been found to contain 140 million capable of developing on gelatine, in addition to those which are not. A rich garden soil contained three or four times as many.

Most bacteria derive their energy from the oxidation of organic matter, but there are a few very remarkable exceptions. The nitrifying organisms apparently make little use of organic matter—they may indeed be injured by it—and derive their carbon from carbonic acid, which they decompose without the aid of sunlight or the intervention of chlorophyll. Apparently the necessary energy is obtained from the oxidation of ammonia to nitrous or nitric acid. The oxidation of ferrous carbonate is supposed to furnish energy to Cladothrix and Crenothrix, while the oxidation of hydrogen sulphide affords energy to the sulphur bacteria.

The work of the soil bacteria is, in properly drained and aerated soils not too rich in organic matter (see § 21 (1)), almost entirely beneficial to the plant. Through their activity plant residues, leaves, stems, &c., useless or rather harmful to the plant because they open up the soil too much, are converted into useful plant food and valuable humus. Their activity may be estimated by counting their numbers (see Bacteriology), or by determining the amount of oxygen they absorb (see Oxidation in Soils). In ordinary soils they are kept in check by protozoa-like organisms. If the soil is treated with some volatile antiseptic such as toluene or carbon disulphide, or if it is heated to 70° to 100° C., these organisms, along with the living bacteria, are killed, but not the spores. After the antiseptic has volatilized, or the heating ceased, the spores begin to sporulate, and the resulting bacteria, having now a clear field, multiply rapidly, and reach far higher numbers than before. The new organisms appear to be enfeebled by the treatment, but in virtue of their higher numbers they produce an increased amount of plant food, which causes an increase in crop. The following are some of the results of pot experiments by Russell and Darbishire:—

	Mustard.		Buckwheat.			
	Untreated Soil.	Heated Soil.	Untreated Soil.	Soil treated with Carbon Disulphide.	Soil treated with Toluene.	Soil treated with Chloroform.
Weight of dry matter per pot	15·88	24·33	18·14	23·27	20·98	25·08
Weight of nitrogen taken by crop ...	0·37	1·08	0·50	0·73	0·63	0·73
Weight of phosphoric acid taken by crop	0·16	0·51	0·34	0·54	0·45	0·61
Weight of potash taken by crop	0·67	1·22	1·02	1·39	1·21	1·41

Compare also Russell and Hutchinson, Journal of Agricultural Science, 1909, p. 111.

No method suitable for farm practice has yet been devised.

Attempts have been made to increase the bacterial activity of the soil by adding special organisms. The bacteria associated with leguminous crops have been especially the subject of experiment, as also the ammonia-producing organisms (see Inoculation of Soil). New leguminous crops growing for the first time have benefited by this treatment.

Bacteria can to a certain extent move in the soil, but not rapidly. An effective way of removing bacteria from water, and one used to a considerable extent in purifying drinking water or sewage effluents, is to filter it through soil or sand. Unfiltered Thames water was found to contain 2500 bacteria per cubic centimetre; filtered water only about 20 on an average. Reference has already been made to the removal of organic matter from water effected by soil, which further contributes to the purification of the water.

The Changes taking Place in the Soil

§ 16. The Inorganic Materials.—The complex silicates of the soil decompose very slowly under the influence of carbonic acid and water. See Soil, Geology of. So far as is known only three of the mineral constituents of the soil undergo change sufficiently quickly to be of agricultural significance, viz. calcium carbonate,

calcium nitrate, and silicates of the zeolitic type. These changes are in part due to natural agencies and in part to the mineral manures added to the soil.

§ 17. The *calcium carbonate* in the soil suffers a greater number of changes than any other mineral constituent: (*a*) It reacts with carbon dioxide to form calcium bicarbonate, which washes down into the subsoil and is lost. (*b*) It reacts with ammonium salts added as manure thus: ammonium sulphate + calcium carbonate = ammonium carbonate + calcium sulphate. The calcium sulphate being soluble, washes out and appears in the drainage water. (*c*) It is utilized by the nitrifying bacteria and converted into calcium nitrate. These changes cause at Rothamsted a loss of about 800 lb. of calcium carbonate per acre each year, or more if ammonium sulphate is added. Calcium carbonate does not sink in arable soil, but washes right away.

§ 18. *Calcium nitrate* is perhaps the most fluctuating of all the mineral substances in the soil. It is formed during nitrification, but readily washes out of the soil; the amount present at any time depends largely on the rainfall of the preceding days. It is taken up by plants, but suffers decomposition during the process, so that calcium carbonate is left behind in the soil. There is thus a cycle of changes: calcium carbonate is converted into nitrate by the nitrifying bacteria; calcium nitrate is converted into carbonate by the plant. A similar change takes place when sodium nitrate is added as manure: the nitrate radicle is absorbed by the plant, and sodium carbonate is left behind in the soil. It is important to notice that neither ammonium salts nor nitrates permanently remain in the soil; thus they do *not* increase the percentage of soil nitrogen.

§ 19. *Silicates of the Zeolitic Type.*—These are supposed to liberate some soluble potash compound by a change not understood, and to react with salts of ammonia, sodium, calcium, magnesium, &c., that may be added as manure:

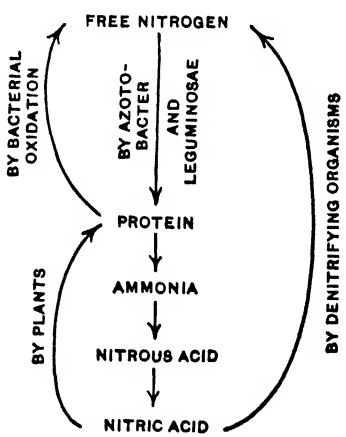
Complex silicate of lime, &c. (insoluble) + Sulphate of potash (soluble)
= Complex silicate of potash, &c. (insoluble) + Sulphate of lime. (soluble)

(See Manures, Effect of on Soil.) Soluble potash manures added to the soil are not washed out, but are converted into insoluble substances, which, however, are not too insoluble for plant nutrition. Addition of lime accelerates the rate of solution by actually displacing some of the potash. The insoluble combination formed from sulphate of ammonia added to the soil does not appear to be an ammonium compound.

Important changes in the mechanical condition of the soil take place as a result of some of the reactions. The calcium bicarbonate as it washes down flocculates the clay and improves the texture. On the other hand, the sodium carbonate formed from sodium nitrate deflocculates the clay, and produces unkindly conditions and a glazed appearance on soils deficient in coarse sand.

The changes resulting in the formation of alkali soils are discussed in art. Alkali Soils.

§ 20. The Organic Materials.—In normal healthy conditions the roots of living plants are not attacked by the inhabitants of the soil, but when the plant dies it is attacked by a great variety of organisms and rapidly disintegrated. The details of the change are not known, and are doubtless highly complex. The final products are water, carbonic acid, black colloidal substances known as humus, probably some residues which will not further decompose, ammonia, some free nitrogen which escapes and is lost. The changes of the nitrogen compounds are of great importance. We may suppose that the protein is resolved into amino acids, diamino acids, and purin bases, as in the ordinary hydrolysis, and these are changed into ammonia by bacteria. However, the ammonia does not persist, but is either absorbed by some of the clay constituents (§ 19), or is attacked by the nitrifying organisms to form nitrites and then nitrates. Nitrification takes place so quickly that we never find either ammonia or nitrites in the soil; it is apparently the quickest of all soil changes, and is only limited by the speed at which the ammonia-producing organisms work. The whole process would be entirely beneficial to the plant were it not for the evolution of a certain amount of free nitrogen. At the same time the nitrogen-fixing organisms, azotobacter and others, absorb a certain amount of free nitrogen, making it into protein. A considerable amount of energy is required for this change, and is derived from the oxidation of organic matter. We may represent the cycle of nitrogen changes in the soil diagrammatically as follows:—



These processes are specially active in moist, well-aerated soils; the production of nitrates during a well-worked fallow is one of the chief effects produced. There may be a loss of nitrate or ammonia under certain conditions through their assimilation by lower organisms.

§ 21. The cases arising in practice may be summed up as follows:—

(1) Decomposition becomes very active when

land rich in organic compounds of nitrogen is subjected to arable cultivation: the land loses organic matter and nitrogen rapidly. Heavily dunged land or newly broken rich prairie soils afford excellent illustrations. The changes in nitrogen content of some of the Rothamsted soils during a period of twenty-eight years are as follows:—

	In Soil, 1865.	In Soil, 1893.	Loss in 28 years.	Added by Rain and Seed.	Added in Manure.	Removed by Crop.	Unaccounted for.
	lb.	lb.	lb.	lb.	lb	lb.	lb.
Plot 3—No manure ...	2722	2437	285	167	Nil	428	-24
„ 7—Minerals and ammonium salts	3034	2971	63	167	2408	1212	-1426
„ 2—Dung	4343	4976	633 (gain)	167	5600	1361	-3773

It will be observed that the ammonium salts have not increased the percentage of nitrogen in the soil. Any that have not been taken up by the plant have been washed out as nitrates. On the dunged plot only one-quarter of the added nitrogen is recovered in the crop, and more than half is lost.

Shutt found the following changes in nitrogen content of cultivated prairie soils:—

Indian Head, Sask.

	Nitrogen			
	To a depth of 4 in.		To a depth of 8 in	
	per cent	lb. per acre	per cent.	lb per acre.
Virgin soil	0·409	3284	0·371	6936
Cultivated 23 years, including 9 fallows	0·257	2402	0·253	4730
Loss due to removal in crops and to cultural methods	0·152	882	0·118	2206

Only about one-third of this loss is to be accounted for by removal in grain and straw of the crops grown, the remaining two-thirds being dissipated as a result of cultural operations. Something similar has happened in England: ordinary arable soils now contain about 0·15 per cent of nitrogen, but the woodland or grass soils from which they originated usually contain about ·25 per cent.

(2) In the case of arable land continually carrying cereal crops, the nitrogen content declines when the produce is entirely removed and no nitrogen compounds are added as manure or through the cultivation of leguminous crops. The decline is at first greater than the amount of nitrogen in the crop, but finally becomes approximately equal to it.

(3) Where a leguminous crop is introduced into the rotation the nitrogen content of the soil may be maintained, or even increased, without the addition of any nitrogenous manure. Thus under the old four-course rotation, in which clover comes in once every four years, the percentage of nitrogen in the soil does not fall indefinitely, but reaches a level at which it remains tolerably constant. By altering the frequency with which leguminous crops are taken, it becomes possible to keep the nitrogen at any level within certain limits. This conclusion may be illustrated from the results given by the Agdell rotation field at Rothamsted, where clover or beans are grown once in each four years. The nitrogen statistics for the plot that receives no nitrogen but only phosphoric acid and potash are:—

Nitrogen in Soil			Average Production				Average Removal of Nitrogen per Acre.
1867.	1909.	Gain per Acre per Annum.	Wheat.	Swedes.	Barley.	Clover.	
lb.	lb.		bus.	cwt.	bus.	cwt.	
3240	3522	+ 6·7	35·2	227	29	46·7	46·3

Had the roots, straw, and clover been converted into manure and returned to the land, as would be the case in ordinary farming, there is little doubt but that the production would be raised to a higher level.

(4) When land is carrying a vegetation that is not removed there is a gain of nitrogen, which, however, does not go on indefinitely, but is finally balanced by the losses.

Land allowed to run wild and go back to prairie state at Rothamsted showed the following nitrogen changes:—

Nitrogen, lb. per Acre, Top 9 in.

In Soil, 1881.	In Soil, 1904.	Added by Rain, 23 years.	Gain.
lb.	lb.	lb.	lb.
2769	3711	88	854

Land laid down to grass steadily gains nitrogen for many years:—

Arable land	·124	per cent of nitrogen.	
Grassland laid down 11 years	·151	,,	,,
Grassland laid down 29 years	·174	,,	,,
Grassland laid down 45 years	·195	,,	,,
Very old pasture ...	·247	,,	,,

The extent to which accumulation will go on depends on the rainfall; thus it is found that prairie soils in arid regions contain less nitrogen than those in humid regions. In this, as in several other directions, climate is an important factor in soil formation.

Both fixation and loss of nitrogen probably go on in most soils, and prevent either an indefinite accumulation or an absolute removal of all of this constituent. Finally, a state of equilibrium is reached, and the soil does not alter until the conditions are changed. See also arts. Nitrification, Nitrogen Fixation, &c.

§ 22. Absorption of Substances by Soil.—It has already been pointed out that certain soluble substances react with soil constituents to form compounds. These are: (1) ammonium sulphate, (2) potassium salts, (3) soluble organic matter, (4) phosphates, (5) compounds which react with calcium carbonate or bicarbonate to form insoluble carbonates, *e.g.* copper sulphate, &c.

The following are *not* absorbed: (1) nitrates, (2) calcium bicarbonate, (3) sodium salts.

§ 23. Action of Rain on Soil.—Rain washes out nitrates from the soil and thus effects a temporary diminution in productiveness. A wet winter is known to be bad for the wheat crop. At Rothamsted, fallowing leads to a marked increase in the yield of wheat only when the rainfall has not been too high.

	Sixteen Seasons less than Average Rainfall (8·9 in. from Sept. to Dec. inclusive)	Sixteen Seasons *more* than Average Rainfall (13·7 in. from Sept. to Dec. inclusive).
Wheat grown after fallow, total produce in lb. ...	2743	1757
Wheat grown after wheat, total produce in lb. ...	1810	1627
Increase due to fallowing, in lb.	933	130
Percentage, increase due to fallowing	51·5	7·9

(Hall, Book of the Rothamsted Experiments, p. 64.)

Catch cropping or bastard fallowing affords an excellent means of saving these nitrates. Rain has a mechanical effect in beating down the soil and giving a glazed appearance. It causes clay and strong loams to swell, but this effect is noticed much less than the converse effect of drought, which causes the same soils to shrink and therefore to crack. Further, it washes some of the fine clay material from the surface into the subsoil; this process has been going on ever since the soil was formed, and has led to the following order of differences:—

Percentage of Clay

	Sandy Soil.	Sandy Loam	Loam.	Clay.
In top 9 in. ...	3·6	7·1	9·2	20·0
In second 9 in. ...	5·0	10·2	14·2	29·0

Irrigation accelerates this movement, and the clay washed down forms in time an 'irrigation hard pan' which has to be broken. This change introduces a disturbing factor into experiments with lysimeters or drain gauges (Russell, Jour. of Agricultural Science, 1907, vol. ii, p. 29).

§ 24. Frost.—The chief effect is to break down hard clods of earth by causing the water inside the clod to freeze and expand. The force of the expansion is enormously greater than anything else at the farmer's disposal, and, acting as it does on every particle of the soil, it is remarkably effective in mellowing down unkindly soil. Any mineral like chalk that admits the entrance of water into its pores may in like manner be shattered. Fragments of rock are splintered off and disintegrated; this action is only very slow, but it has great results in the long ages of geological time.

§ 25. The Movement of Air in the Soil.—Life in the soil is only possible in so far as air is able to get in. The mineral particles of various sizes forming the bulk of the soil have not settled down into the most compact position. The air passages thus left form about half the soil, and are still further increased by cultivation in arable land, by the movements of worms, &c., in pasture land, and by frost.

Air gets into the soil by diffusion, but the process is retarded by the smallness of the pore spaces and the friction. Carbonic acid, nitrogen, and water vapour diffuse out of the soil, but at unequal rates; water vapour goes quickest and carbonic acid slowest. In consequence of the slow rate of diffusion there is always a marked difference in composition between the gases of the soil and of the air, especially in the proportions of carbonic acid. The atmosphere contains 0·03 per cent of carbonic acid and 20·97 per cent of oxygen; the air of the soil may contain ·3 of carbonic acid and 20·6 of oxygen. As the carbonic acid is produced partly by micro-organisms and partly by plant roots, its amount varies with the temperature, being highest in summer and lowest in winter. (See Wollny, Die Zersetzung der Organischen Stoffe, p. 145; and Lau, Biedermann's Zentralblatt, 1908, vol. xxxvii, p. 433.)

Diffusion is not the only way in which the air of the soil is changed. An actual flow of air from the soil is induced by a strong wind or by changes in barometric pressure. Air is also

displaced by the water of a sharp shower sinking into the ground; indeed the bubbling of the air through the water can often be heard after the shower has stopped. As the water runs away into the subsoil, air again enters to take its place.

§ 26. The Movement of Water in the Soil.—The factors regulating the movements of water in the soil are more complex than those regulating the movement of air; not only are the pore spaces involved, but also the surfaces of the soil particles and the amount of organic matter present. The surface of a liquid possesses certain special properties, in consequence of which the liquid wetting a *dry* clean solid tends to spread over as large an area as possible. This tendency is checked, or may even be put out of action, if anything such as grease is present which hinders or prevents the wetting of the solid. Water moves freely over the surface of clean, but not of greasy sand, while it will only with difficulty moisten dry peat or dry garden soil. Dry arable soils are more readily moistened, but the water does not spread far

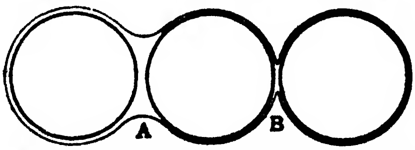


Fig. 1.—Diagram showing water films round solid particles. Water tends to pass from A, where the film is thick and the curvature flat, to B (§ 26).

unless it is in considerable excess; a moist layer of soil may remain for a long time in contact with a dry layer without any even distribution of water taking place. But the case is altogether different when the particles are already moist. One of the results of the surface tension of liquids is that the liquid on wet particles in contact with one another passes from places as at A (fig. 1), where the capillary films are thick and consequently the curvature flat, to places as at B, where the films are thin and consequently the curvature is sharp. The forces involved are much greater than that of gravity; the water is held up and does not sink. Thus throughout a moist soil that is quite uniform in texture the water tends to distribute itself evenly. It may take a long time about this process because of the resistance to its movement, and in practice the even distribution may never be realized; but the tendency is always there. Unfortunately no experimental demonstration has yet shown how far it is an important factor in the distribution of water. In any case, once water reaches a particle it remains there. There is, however, a limit, depending on the extent of the soil surface, to the amount of water that can be held in this way. When this limit is reached any further quantity of water soaks through and is said to percolate. We may therefore distinguish three conditions in which water may occur in the soil: (1) water held in quasi-chemical combination, the so-called hygroscopic moisture, of no value to the plant (§ 26); (2) the water adhering to the surfaces of the particles by surface tension, which tends to distribute itself in the soil in all directions; (3) the free water, which, not being held, sinks in the soil and passes into the drains or the subsoil. Three cases commonly arise in practice:—

(a) *Coarse Sandy Soil.*—Rain readily percolates by reason of the large spaces. The amount adhering to the surface is not very great because of the small total soil surface (see § 3). The films surrounding the particles are only thin, too thin indeed to move readily. Evaporation is also taking place, and makes the films still thinner. Only where there is enough free water for the films to be fairly thick will there be much water movement of the kind we have just been describing. Soils of this nature, therefore, do not remain moist long after a shower, unless the water-level happens to be near the surface. Their productiveness depends very much on how far the rainfall is uniformly distributed over the growing season.

(b) *Clay Soil.*—In a clay soil, on the other hand, the particles are very much smaller, but there is a largely increased surface. In consequence, the amount of water that can be held is increased; indeed a clay soil will often be found to contain twice as much water as a sandy soil close by. But the particles are so closely packed that the movement of the water films is seriously impeded. Thus a clay soil may be saturated with water at a short distance down and yet on its surface show every sign of drought. Matters are improved by flocculating the clay by lime or skilful cultivation; or, on the other hand, they become much worse when the soil is badly managed so that the clay becomes deflocculated (§ 3). One of the advantages of autumn ploughing is that the rainwater has a better chance of soaking into the soil, instead of lying about in pools all through the winter.

(c) The third case is presented by the intermediate types of soil, where the total surface, and therefore also the water held by the surface, is greater than in sand but less than in clay. The pore spaces are large, and there is therefore more chance for water to distribute itself both by percolation and by the transference of water from particle to particle. The water supply is therefore better than in either of the other types of soil.

§ 27. The amount of water retained by the soil is considerably increased by the addition of organic matter. The water held by the dunged plot on Hoos field, Rothamsted, and the neighbouring plots receiving no dung, was found to be:—

	April 6, 1909.	May 7, 1909.	July 6, 1909.	Oct. 28, 1909.
Dunged plot	20·0	18·0	20·7	23·3
Complete artificials ...	13·7	13·2	14·9	18·9
Unmanured	13·1	12·9	13·6	17·8

By using large amounts of dung, market gardeners are able to utilize to advantage light sandy soils. But it has been pointed out that organic matter increases the difficulty of wetting the soil; and in old garden soils this diffi-

culty sometimes becomes so marked that the plant fails to get a proper water supply. Such soils are said to be 'worn out'; they may be renovated by heavy dressings of virgin loam.

We have seen that when rain falls on the soil it distributes itself throughout the soil; every particle holds a certain amount, and the whole quantity held in every inch of soil depends on the surface of the particles and the amount of organic matter. As the surface soil contains far more organic matter than the subsoil, there is a tendency for the water to remain near the surface; but during the autumn and winter months more rain falls than can be held there, and a certain amount percolates, reaching the drains and finally the rivers. The whole process is slow. The rainfall in the Thames valley is at a maximum in October, but the river is only at a maximum flow five months after; the rainfall is at a minimum in April, while the river does not reach its minimum flow till September. Even at the surface it is not rapid; drains will often not start running till some time after a heavy rain; if the land receives much dung they may not run at all.

§ 28. The water held by surface tension constitutes the supply for the plant, and has therefore to be carefully conserved. Evaporation from the surface of the soil and from the interior causes serious loss, amounting at Rothamsted to about 18 in. each year. The evaporation from the surface, which is by far the greatest amount, can be reduced by windbreaks, by a covering of vegetable matter, shade-giving plants, or even a layer of dry soil. High hedges act as windbreaks and keep the roads from drying: they are therefore discouraged by the authorities. The protecting effect of a layer of dry soil (made by hoeing or by surface cultivation) is utilized in temperate climates, both in regions of moderate and of low rainfall, for keeping the soil moist enough to produce a crop. In the Tropics the best method for keeping down evaporation is to shield the soil by means of shade-giving crops; whilst in ordinary garden practice, mulching with dung, straw, &c., may be suitable. On the other hand, anything which opens up the soil increases the amount of evaporation. The use of long dung on light land in a dry season is known to be injurious (see art. CULTIVATION, EFFECT ON SOIL). Thus we can to a certain extent control the fate of the water in the soil. The water-holding capacity of the soil can be increased by adding organic matter, *e.g.* by adding dung, ploughing-in green crops, or feeding crops on the land. A larger proportion of the rain is now held near the surface, and a smaller amount lost by percolation. Loss by evaporation is reduced by surface cultivation or by mulching. Further, water is held below the surface layer by keeping the lower depth compact. These are the principles underlying 'dry farming', which has been practised from time immemorial in arid regions. In Syria, where no rain falls from April to October, the peasants plough to a depth of 4 in. only, and then put seed into the firm layer below, which is always moist. The same principles can be traced in the methods in vogue amongst the natives of the dry parts of India. Dry farming is being much developed in the United States and Canada, where special instruments are in use for compacting the lower soil and making a loose layer on the surface. Often the land is only cropped once in two years, and is kept well cultivated during the interval to preserve for the crop as much as possible of the two years' water supply.

§ 29. It would be interesting to ascertain whether the permanent water-level affects the fertility of the soil if it is well below the root range of the plant. There are many instances of light soils being productive when the water-level is some 50 ft. or more below the surface, whilst on some of the heavier soils the water-level may be 150 ft. down or even lower. The pumping operations going on all round London are lowering the water-level in the chalk from 12 to 18 in. each year. Will this in time affect the productiveness of the soil above? It cannot be said that we know sufficient to answer this question. The amount of water held by the surface of the soil is considerable, and the percolation of the rest is so slow that a saturated zone easily forms near the surface. Possibly this is all the plant ever gets. It is this saturated zone that sets the drains running, even though the water-level in the wells may be many feet down. We must again repeat that there is no direct experimental evidence to show how far the undoubted tendency to move upwards from the permanent water-level is a factor in determining soil fertility.

§ 30. The percolation through the soil is downwards; there is not much movement sideways. On Dungeness, a low-lying sandy and pebbly level stretching out into the sea, the water from the cottagers' wells sunk quite close to the sea is practically pure rain water, showing no signs of admixture with sea water. Further, it is a common experience that one can see 'to an inch' where a soluble fertilizer like nitrate of soda has gone. But the direction of percolation may always be altered by a bed of impermeable rock; the water may be thrown out to form a spring or may drift underground. In any case there is always an underground drift along sloping ground, so that the valley is moister than the higher ground.

§ 31. There is a certain amount of distillation of water from the lower to the upper layers of soil whenever the lower soil is warmer than the upper. This happens frequently, but its effects are very noticeable in dry regions during the cold nights following after warm days. Not all the water condenses in the surface soil; some passes as vapour into the cold air and condenses there. Thus is formed the night mist so much extolled by the old Eastern writers: 'the mist that went up from the ground and watered the whole face of the earth'.

§ 32. THE TEMPERATURE OF THE SOIL.—The temperature of the soil depends on the amount of heat it receives, and on the way the heat is used. The heat comes of course from the sun, but some is absorbed on the way by the air and the moisture in the air, so that the amount finally reaching the earth's surface depends on the climate. The amount received on any given

area of ground depends on its slope with respect to the sun's rays; a square yard of level ground at the Equator receives more than a square yard, also level, in a northern latitude. In the latter case an alteration in the slope increases the amount received up to the point where the sun's rays strike vertically; but even then the amount is far less than at the Equator by reason of the greater thickness of air traversed. If the slope is the other way, *i.e.* to the north instead of the south, there is a still further decrease in the heat received per square yard (see fig. 2); the difference in temperature becomes very important in districts where early produce is raised. In some cases, as in Jersey, a south slope fetches a higher rental than a north slope. Ridging land also increases the surface exposed to the sun and therefore warms it. On the other hand, soil shielded from the sun's rays is cooled during spring and summer; thus forest soils are the coolest, pasture soils come next, whilst arable soils not covered with a crop are warmest. In winter, however, the reverse obtains, as we shall see later on.

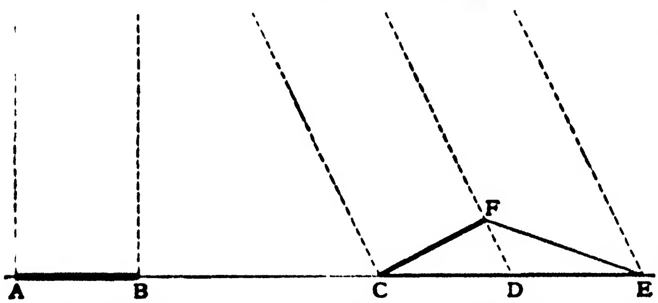


Fig. 2.—Diagram indicating, by the thickness of the lines, the relative amounts of heat received per square yard at the Equator (A B); in Northern latitudes on level ground (C D, D E); on ground sloping to the South (C F) and to the North (F E). C F receives less heat than A B because of the greater thickness of the atmospheric layer which has to be traversed (§ 32).

§ 33. The heat falling on to a surface of soil is not all absorbed; part is reflected back into space. Black surfaces absorb most heat; the practice of dressing fields with soot in spring therefore tends to increase the temperature besides supplying nitrogenous manure. White surfaces reflect most heat, however, and therefore a white soil is cooler during hot summer weather than a black one.

§ 34. The soil is always giving out heat by radiation, even on the hottest day. During a warm, sunny day it receives more than it gives out, but on a cool night or in winter it gives out more than it receives, and so its temperature falls. Still more serious is the loss of heat arising from the contact of cold air particles; as the air touches the warm surface of the soil it takes away some of the soil heat and rises, giving place to more air, which robs a further portion of the soil heat. This is called loss of heat by convection. Both sources of loss are diminished if the soil is covered with a crop, or a mulch, or a loose snow layer. Thus, in the winter time, mulched land is warmer than open land, and grass land is warmer than arable. But a mulch reduces the temperature in spring by keeping off the sun's rays, and in garden practice where autumn mulching is adopted it must be removed or dug in before the sunny weather starts. Loss by convection is greatest when a cold wind is blowing. Shelter from cold winds is therefore an important factor in determining soil temperature.

§ 35. So far we have only been dealing with the temperature changes at the surface of the soil. It is necessary, however, to follow the changes in the soil itself, or at any rate in the top 6 in. where the plant roots develop. Heat penetrates into the soil in two or three ways. A certain amount is conducted, just as heat is conducted along a poker one end of which is in the fire. This process is only possible where the particles are in contact, hence a compacted soil conducts heat better than a loose one. Thus rolling land in spring warms it, while hoeing in summer cools it; further, compact land is colder in winter than loose land. A moist soil is a better conductor than a dry one, because water makes a better conducting layer than air.

Conduction takes so long that the temperature of the soil never equalizes itself at different depths. There is always a difference between surface and subsoil. From September to March the subsoil is warmer than the surface soil, and thus the soil is being warmed from below.

The heat reaching the soil is utilized partly in raising its temperature and partly in causing evaporation of the soil water. The quantity required for raising temperature depends partly on the specific heat of the soil, but mainly on the amount of water, since 1 lb. of water requires as much heat to warm it one degree as 6 or 8 lb. of soil. But the heat required to evaporate water is far in excess of that required to warm it: the evaporation of 1 lb. of water takes as much heat as would warm 1 lb. of dry soil 90° F. Thus the evaporation of water from the soil not only leads to a loss of water, but to a much more serious loss of heat; it is a wasteful process, without any compensating advantages as far as is known. A dry soil may warm less quickly, but it warms to a greater extent than a wet soil; draining a soil will therefore always warm it.

§ 36. We may sum up the factors concerned as follows:—

(1) The heat all comes from the sun and strikes the surface of the earth. The slope of the surface is therefore important.

(2) Part is reflected and part absorbed, the amount absorbed depending on the colour of the soil.

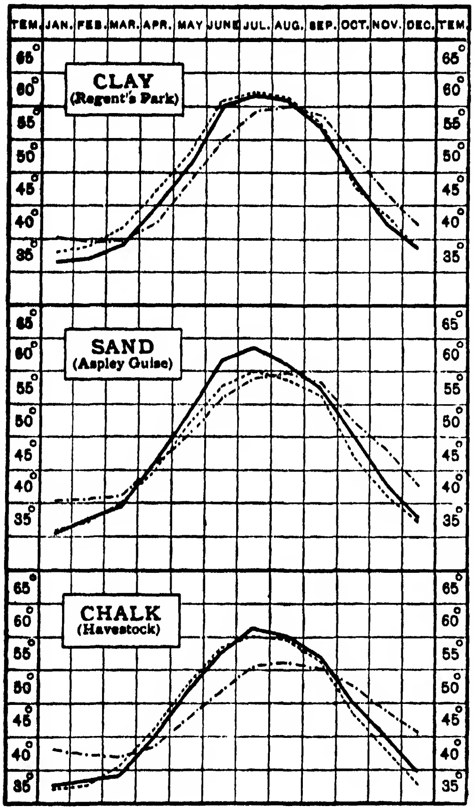
(3) Some is lost by radiation, and more by the passage of cold air over the surface.

(4) Heat travels into the soil by conduction,

which is greater the more perfect the contact between the particles, *i.e.* the more compact the soil.

(5) The effect of the heat depends on the amount of water present; a wet soil requires considerable heat to raise its temperature, and uses up still more heat in bringing about evaporation.

The effect of these various factors may be



-------- *Air Temperature*
——— *Soil Temperature at 1 foot deep*
-·-·-·- *Soil Temperature at 4 feet deep*

Fig. 3.—Curves showing temperatures of sandy soil, clay, and chalk soil (Mawley) (§ 36). Observe that (*a*) the clay 1 ft. is colder than the air until June, but from then onwards it has the same temperature; (*b*) the clay at 4 ft. is warmer than the air and the surface soil from September to March; (*c*) the sandy soil at 1 ft. is warmer than the air except from December to March; in summer it is much warmer; (*d*) the chalk soil at 1 ft. is somewhat cooler than the air up to June, and somewhat warmer afterwards; (*e*) at 4 ft. sand and chalk temperatures behave like clay temperatures.

very well seen by watching the melting of the snow. Even on an apparently uniform field the snow melts very irregularly in consequence of small differences of slope or shelter. If the fall of snow has come late so that the ground has been cooled beforehand, the snow lasts longer on the arable than on the warmer grass land; it lasts still longer on a footpath across the fields, which, being compact, has lost much of its heat by its superior conducting power. The reverse often holds, as one might expect, for an early fall of snow. Snow melts first along the lines of drainage and on the ridges, these being the warmest parts of the field. It often melts close to the ground, and while the upper surface remains intact, because of the heat conducted up from the subsoil.

A sandy soil being drier, is warmer than a clay soil in spring and summer, but not during winter. Mr. Mawley has drawn up the curves given in fig. 3 expressing these relationships. Other results are quoted in art. Fertility.

There is obviously no possibility of increasing the total supply of heat, but the following methods are in use in various circumstances for making the most of the available supply:—(1) The amount of heat received per square yard is increased by ridging; (2) the amount absorbed is increased by dressing with soot; (3) the loss is reduced by (*a*) drainage, (*b*) making windbreaks. The temperature of the soil is raised in spring by rolling, and is kept down in summer by surface cultivation, by a growing crop or a mulch.

The Soil in its Relation to the Plant

§ 37. The Functions of the Soil.—In relation to the plant the soil serves several functions. Among others (1) it affords anchorage for the roots; (2) it supplies many of the elements of plant food; (3) it affords a continuous supply of water to the root; (4) it serves to keep the root cool during summer and warm during winter.

In order that firm roothold should be provided for the plant it is necessary that the soil should be sufficiently compact. We can thus explain part of the beneficial effect of rolling wheat or grass in spring, especially after frost has loosened the ground.

The plant derives its nitrogen and its mineral matter from the soil. The amount it takes up is not great — ordinary farm crops take 50 to 100 lb. of nitrogen,[1] 20 to 30 lb. of phosphoric acid, 30 to 100 lb. of potash[2] per acre, quantities far smaller than actually exist in the soil. Few soils will contain less than 2500 lb. of nitrogen on the top 9 in.—this is the amount present on the Rothamsted plot cropped every year without any manure since 1839—and yet in most cases addition of the 18 lb. of nitrogen contained in 1 cwt. of nitrate of soda will lead to an increased crop. We are thus led to conclude that a large part of the combined nitrogen of the soil is of no use to the plant. In like manner the amounts of phosphates and of potash in the soil are much in excess of anything the plant can ever require; yet it will often happen that a few additional pounds in the form of some artificial manure lead to an increased plant growth. The amounts of these substances in the soil *actually serviceable to the plant* are clearly nothing like as great as the total amount, and a distinction is therefore made between the 'available' and the 'unavailable' plant food in the soil.

The distinction is not a very sharp one. At Rothamsted, where wheat and barley are grown

[1] Cereals take about 50 lb.; mangolds (22 tons) about 100 in the roots.

[2] 22 tons of mangolds contain 222 lb. of potash in the roots.

in adjoining fields under apparently identical conditions, the wheat finds in the soil all the phosphates it wants, while the barley does not. Consequently wheat does not respond to dressings of superphosphate, while barley stands in great need of it. The amounts of phosphate actually contained in the two crops are practically the same (about 21 lb. of P_2O_5 in average crops); the difference is due to some peculiarity in the plant itself. These and parallel cases show the impossibility of sorting out the soil into two parts, one being available plant food and the other not available. Any potassium compound that will dissolve in the soil water is to that extent a possible plant food. Experiments with various potassium minerals show that they can all supply some food to plants; all are available, but in very varying degrees. The only possible measure of the available plant food would be the product of the surface and the solubility of the various soil compounds. Potash presents us with the simplest case in which 'availability' is the same as 'solubility' so far as is known. The phosphorus compounds afford a more complicated case. The soil contains phosphates of varying solubility and therefore availability, but it also contains other phosphorus compounds, the actual nutritive values of which differ among themselves. Thus the organic body lecithin is said to be a useful plant food, whilst nuclein has much less value. Nitrogen furnishes perhaps the most complex case of all. The simple compounds that serve as plant food are all of them produced by bacterial action from more complex compounds, and probably all of them are converted into nitrates before the plant gets hold of them. The actual amount of nitrogenous plant food produced therefore depends on the activity of the bacteria as well as on the nature of the complex compounds. A possible classification would be based on the age of the organic matter, fresh organic matter being more likely to decompose and yield plant food than old; but no practical method has been devised.

In practice, an estimate of the available potash and phosphoric acid is obtained by extracting with a dilute acid. One-per-cent citric acid is used in England, but others are adopted elsewhere (see SOIL ANALYSIS). The results are necessarily only comparative, and merely enable us to compare one soil with another. No estimate of the 'available' as distinct from the total nitrogen is usually attempted.

§ 38. *Water Supply.* — Water is an essential plant food, and forms 90 per cent of the weight of the growing crop; it also keeps the plant turgid. It is equally necessary in the soil itself. It dissolves the foodstuffs in the soil to make the solution on which the plant feeds. It is also wanted by bacteria; indeed the amount of decomposition they effect and of plant food they produce is largely regulated by the amount of water present. Soils vary considerably in the amounts of water they supply to the plant. A sand gives up almost all it has, retaining only about 2 parts for every 100 of dry soil. A clay may keep back as much as 10 per cent, while a peat keeps back something like 50 per cent. So far as the plant is concerned, a sand containing 12 per cent of water might be just as moist as a clay containing 20 per cent or a peat containing 60 per cent. Heinrich grew plants in pots of various soil, and finally left them without water till they wilted. At this stage the soils were found to contain the amounts of water shown below:—

WATER PER 100 OF DRY SOIL.

	Present in the Soil when Plants Wilted.	Absorbed from Moist Air.
Coarse sandy soil ...	1·5	1·15
Sandy garden soil ..	4·6	3·00
Fine humus sand ..	6·2	3·98
Sandy loam ...	7·8	5·74
Calcareous soil ..	9·8	5·20
Peat	49·7	42·30

The 'unavailable' water is mainly 'hygroscopic water', *i.e.* the water still retained by the soil after it has been dried in air, or, what is nearly the same thing, the amount of water absorbed from moist air. This depends on the amount of decomposing organic matter and on the total surface of the soil, factors which, as we have seen, profoundly affect other properties determining the fertility of the soil, such as water supply, temperature, production of plant food, and so on. Thus there is something to be said for Davy's view that the amount of moisture absorbed from damp air affords a comparative index of the fertility of the soil.

A second factor influencing the amount of water supplied to the plant is the amount of soluble matter in the soil. Water passes from the weaker solution to the stronger, and only goes from the soil to the plant so long as the plant sap forms a more concentrated solution than the soil moisture. If a plant is put into a strong sugar solution it quickly wilts, the water flowing outwards from the plant. So wet, boggy ground containing a good deal of soluble matter does not actually yield a great deal of water to the plant.

The water supply has a profound effect on the native vegetation. Soils where drought conditions prevail — sands because of their coarse structure, peats because of their own powers of sticking to water — carry a vegetation with narrow leaves adapted to small transpiration. On sands we find the Conifers, Ericas, &c. On clays and soils well provided with water we find a broader-leaved type of plant requiring much more water.

So long as the temperature and air supply remain favourable, the greater the water supply the larger will be the total crop. The leaves are kept distended, and the plant can make the most of the food supply in the soil. Copious water supply, however, tends to leaf production and a delayed harvest. Fig. 4 shows two pots of wheat, one of which had been kept well supplied with water, whilst the other had been kept much drier: the difference in stage of maturity and in size of plant is very striking.

§ 39. *The Temperature.*—We have already seen that the temperature relationships of a soil are

conditioned by the amount of water usually present. The same factor largely determines the heat supply in relation to the plant, or, in other words, the 'earliness' or 'lateness' of a soil. An early soil is dry, and therefore warms up more in spring and summer than a moister soil; it is almost invariably a sand, which in any case warms more quickly than a loam or a clay. The tendency for cold air to drift down slopes or to collect in hollows causes vegetation in low-lying places to suffer from frost, and is probably one of the reasons why animals prefer to lie on the highest parts of the field.

§ 40. Calcium Carbonate. — This substance occupies a special position among soil constituents for three reasons: (1) It determines the reaction of the soil; in its absence the soil may be acid, and therefore unsuitable for many agricultural crops and bacteria, but suitable for certain moulds and fungi, such as the fungus causing finger-and-toe, which do not flourish in neutral soils.

(2) It modifies the texture of the soil, and thus improves the air and water supply. A clay soil without calcium carbonate may produce nothing but grass, wheat, and beans. After addition of calcium carbonate a much larger range of crops becomes possible.

A
20 per cent of water present

B
12 per cent of water present

Fig. 4.—Effect of water on the development of wheat. In A the plants were green, with large well-developed leaves, but no corn. In B the plants were yellow and in full ear. (June, 1908) [§ 38]

(3) Unlike the other soil constituents, it may be *entirely absent* from the soil, and in fact large areas all over the world are entirely destitute of it.

Certain plants cannot tolerate calcium carbonate; others, including practically all agricultural crops, require it. Some will tolerate large quantities. Thus we find a chalk soil has a very distinct flora of its own, characterized by large numbers of flowering plants, by beeches, yews, &c. The amount necessary depends on the type of soil: very little suffices on a sandy soil (·05 per cent in some cases), but more is necessary on a clay (·5 per cent or more).

§ 41. The Action of the Plant on the Soil. —The plant acts in two ways on the soil:—

(1) Its roots give off carbonic acid, which is capable of dissolving various minerals, *e.g.* it etches a slab of marble placed in soil in contact with the plant roots. Czapek's numerous observations furnish no evidence that any other acid is excreted.

(2) As already pointed out (§ 18), it decomposes the nitrates to form carbonates, and thus tends to conserve the calcium carbonate and prevent the soil becoming acid.

§ 42. Soil Bacteria in their Relation to Plants.—Bacterial action is on the whole bene-

ficial to plants in removing the useless dead remains and converting them into humus and plant food. Plants in turn are beneficial to bacteria because they tend to maintain the faintly alkaline reaction well suited to bacteria. There are also special cases of plants being associated with particular micro-organisms. The Leguminosæ get their nitrogenous supply more readily through the activity of the nodule organisms than in any other way. Many trees have been shown by Stahl to have mycorrhiza on the roots, by means of which they obtain their food. It has been shown that seedling orchids will not grow unless a special organism is present in the soil; for some reason not understood, the young root cannot do without the stimulus of the symbiotic organism.

§ 43. There is some evidence that the amount of soluble mineral food in the soil increases under the influence of vegetation. Moore extracted the following amounts of phosphoric acid from pot soils in which maize was growing:—

Strength of Hydrochloric Acid Used.	N/200.	N/100.	N/10.	N/5.	N.	2N.	
Phosphoric acid found at beginning of experiment ...	7	12	81	185	350	452	Parts of P_2O_5 per million of soil.
After two weeks' growth	10	16	—	—	—	—	
,, three ,, ...	12	22	108	—	—	—	
,, four ,, ...	12	21	128	219	410	516	
,, five ,, ...	9	16	88	161	334	494	

(Journ. of American Chem. Soc 1902, vol. xxiv, p. 109.)

Inherent Fertility and Condition

§ 44. It is difficult to give any exact definition of fertility beyond the general statement that a fertile soil is one in which plants grow well. When more precise description is attempted, difficulties arise because of differences in plant requirements; the soil may be well suited for one plant but not for another. It is quite possible that every soil is fertile for some crop, although the particular crop may not happen to be saleable. This fact is recognized by the practical man, who will distinguish soils as good wheat soils, good barley soils, and so on.

The difference in plant requirements is, however, only one of degree and not of kind. All plants require (1) food, (2) water, (3) air, (4) warmth, (5) absence of injurious substances, generally secured by the presence of sufficient calcium carbonate. *All these requirements are equally important; if any one of them is unsatisfied, the soil is to that extent infertile.* Excess in any one direction does not entirely compensate for deficiency in any other. No matter how much plant food the soil contains, it may be infertile if its water supply is deficient or if some harmful substance is present. A good water supply will enable the plant to make the most of the foodstuff present, but it becomes a hindrance if the air supply is deficient or the temperature too low. Nitrate of soda is an exceedingly valuable manure in moist climates, but in dry regions it is often without effect; the productiveness being limited by the deficient water supply. At Indian Head, Sask., where the rainfall is only 16·6 in. per annum, dressings of 100 lb. and 200 lb. per acre gave no increased crop; similar results are also obtained in some of the dry regions of South Australia. In all soils we must expect to find one or more limiting factors, which must be put out of action before increases in fertility can be looked for.

§ 45. The quantity of plant food in the soil depends partly on its origin and partly on the temperature, water and air supply. The mineral substances, potash, phosphoric acid, and calcium carbonate form part of the original soil. The organic matter and nitrogen compounds, on the other hand, are mainly recent products of living organisms. The more the conditions are favourable to bacterial activity the more rapid will be the decomposition of organic matter and the production of valuable nitrates, humus, &c.

The water supply depends on two factors: (1) on the behaviour of the soil to the rain that falls on it; (2) on the underground flow of water if there is any. We have already shown that the first of these factors is regulated by the texture of the soil. The ideal condition is for the soil to be uniformly moist, not too wet nor too dry, nor liable to quick changes in water content, which plants will not tolerate. The subsoil is equally important. A soil which might in itself be expected to be fertile may prove poor because it lies on an impervious bed of rock or clay, or because it is overdrained by a pebbly subsoil. The best results are obtained when the subsoil is similar in type to the surface soils but a little finer grained. The underground drift of water is usually only an important factor in soils situated at the foot of a long slope, or in valleys which receive the underground water from the higher land in addition to their own proper share of rainfall. The water is not pure, but contains dissolved mineral matter, calcium bicarbonate, nitrates, &c., of distinct value as plant food. Land thus situated is therefore at a double advantage in comparison with high-lying land.

In soils of sufficiently open texture the air supply is usually good; and, as we have already seen, if the air and water supply are satisfactory, the temperature is also.

§ 46. The texture of the soil thus constitutes a highly important factor in fertility. It is regulated by the proportions of sand, silt, fine silt, clay, &c., and by the condition in which the clay exists. Different crops require different conditions; a type of soil best suited to one crop does not necessarily prove best for another. Certain crops, like wheat and oats, are very adaptable, and may flourish on most types

of soil; others, like barley, turnips, potatoes, &c., are much more specialized in their requirements, and therefore restricted to a particular type of soil. Table I shows the mechanical analysis of a number of soils in Kent, Surrey, and Sussex known to be specially appropriate to certain crops. Of course the results have to be considered in relation to other factors, such as elevation, rainfall, &c. Many good soils may remain in woodland because their elevation

TABLE I.—SOILS IN KENT, SUSSEX, AND SURREY WELL SUITED TO CERTAIN CROPS
(From The Soils of Kent, Sussex, and Surrey, by A. D. Hall and E. J. Russell)

WHEAT SOILS

FORMATION	Thanet Sand.	Upper Green-sand.	Brick Earth.	Clay with Flints.	Clay with Flints.	London Clay.	Alluvium.	Weald Clay.	London Clay.
LOCALITY	Chislet.	Bentley.	Oving.	Loyterton.	Couldson.	Tolworth.	Orgars-wick.	Wood-church.	Sheppey.*
Fine gravel	1·4	6·6	1·2	1·3	2·4	0·5	0·6	0·7	0·7
Coarse sand	5·8	5·4	1·6	1·2	6·8	15·1	0·0	3·0	0·4
Fine sand	35·2	29·7	19·3	35·7	31·4	30·1	35·9	17·1	21·0
Silt ...	36·5	29·0	42·7	29·0	24·3	13·3	22·1	28·2	15·9
Fine silt ...	8·1	14·5	16·1	11·0	11·4	13·1	17·0	27·6	18·2
Clay ...	13·0	14·8	19·1	21·8	23·7	27·9	24·4	23·4	43·8

* This last analysis represents a soil on which good wheat used to be grown, but which has now been laid down to grass for many years.

BARLEY SOILS

FORMATION	Lower Green-sand.	Lower Green-sand.	Thanet Sand.	Lower Green-sand.	Thanet Sand.	Brick Earth.	Chalk.	Lower Green-sand.	Clay with Flints.	Chalk.
LOCALITY	Shal-ford.	Eashing.	Gold-stone.	Repton	Chislet.	Shop-wyke.	Minster.	Alding-ton.	Loyter-ton.	Sutton by Dover.*
Fine gravel	2·7	1·2	0·2	2·8	1·4	0·8	0·6	1·1	1·3	0·6
Coarse sand ...	56·2	52·9	16·4	15·2	5·8	1·0	9·7	19·9	1·2	1·8
Fine sand	28·0	21·4	48·2	48·8	35·2	30·8	38·4	34·1	35·7	16·4
Silt	5·2	7·1	18·6	15·5	36·5	33·5	27·9	11·3	29·0	24·7
Fine silt	3·8	7·1	7·0	7·2	8·1	20·2	7·4	11·3	11·0	7·6
Clay	4·1	10·3	9·6	10·5	13·0	13·7	16·0	22·3	21·8	27·7

* Though this soil contains a rather high proportion of clay for barley, it is kept open and easy-working by the large amount (20·3 per cent) of carbonate of lime that is present.

POTATO SOILS

FORMATION	Thanet.	Lower Greensand.	Bagshot.	Thanet.	Bagshot.	Thanet.	Chalk.	London Clay.
LOCALITY	Swanley.	Nutfield.	Bisley.	Teynham.	Claygate.	Green-hithe.	Minster.	Chessington.*
Fine gravel	1·3	3·2	0·2	0·5	0·8	0·3	0·6	0·7
Coarse sand ...	10·9	50·8	30·9	15·9	27·2	2·2	17·1	19·3
Fine sand	62·3	25·0	49·7	51·8	42·2	75·2	36·4	35·8
Silt	14·2	3·8	5·6	16·1	12·3	4·0	24·6	16·9
Fine silt	5·4	9·6	6·1	5·8	6·7	5·4	6·8	10·2
Clay	5·9	7·6	7·5	9·9	10·8	12·9	14·5	17·1

* Heavy for potatoes, but lightened by good drainage, lime and dung.

FRUIT SOILS

FORMATION	Bagshot Sands.	Thanet Sands.	Thanet Sands.	Brick Earth.	Kentish Rag.	Chalk.	Clay with Flints.	Wealden Beds.	Weald Clay.
LOCALITY	Wisley.	Swanley.	Selling.	Wickham.	East Farleigh.	Minster.	Molash.	Rolvenden.	Sutton Valence.*
	Only nursery stock.	Straw-berries.	Mixed fruit.	Mixed fruit.	Mixed fruit.	Mixed fruit.	Cherries, Apples.	Apples, Black Currants.	Apples, bad.
Fine gravel	0·1	1·3	0·8	0·4	2·7	0·7	1·4	0·4	2·3
Coarse sand	18·1	10·9	5·3	0·9	10·9	9·7	1·6	0·7	4·4
Fine sand	70·1	62·3	60·3	32·4	35·3	38·3	39·2	27·3	12·5
Silt ...	3·8	14·2	15·4	46·7	22·8	27·9	29·2	33·3	15·1
Fine silt ...	4·1	5·4	6·2	8·4	12·9	7·4	11·9	21·9	25·9
Clay ...	3·8	[illegible]	12·6	11·2	15·4	16·0	16·7	16·4	[illegible]

* [illegible] soil is really too heavy for fruit, though apple orchards are found upon it.

HOP SOILS

FORMATION	Thanet Sand.	Alluvial.	Thanet Sand.	Brick Earth.	Lower Greensand.	Clay with Flints.	Brick Earth.	Upper Greensand.	Weald Clay.	Weald Clay.	Wadhurst Clay
LOCALITY	Newington.	Yalding.	Barton.	Teynham.	East Farleigh.	Loyterton.	Ickham.	Bentley.	Rolvenden.*	Woodchurch.*	Ewhurst*
Fine gravel	0·5	3·5	0·3	0·8	2·7	0·9	0·3	6·6	0·5	0·7	3·4
Coarse sand	18·2	14·4	2·5	2·4	11·0	1·3	0·8	5·5	0·6	3·0	2·1
Fine sand	61·6	44·0	38·0	44·2	35·3	28·2	26·3	29·7	27·3	17·1	15·4
Silt ..	8·9	18·2	39·6	29·6	22·8	46·5	47·7	29·0	33·3	28·2	23·8
Fine silt ..	4·3	9·9	6·9	9·7	12·8	8·9	9·2	14·4	21·8	27·6	26·1
Clay ...	6·5	10·0	12·7	13·3	15·4	14·2	15·7	14·8	16·5	23·4	29·2

* These soils only grow the coarser varieties of hops successfully.

makes them wet and cold. Soils which in East Kent (*e.g.* Loyterton and Aldington in the Table) with a rainfall of 24 in. grow excellent barley, prove too heavy in West Sussex with a rainfall of 35 in. or more. On the other hand, the Shalford barley soil would probably be barren waste under a smaller rainfall. A light soil under a heavy rainfall resembles a heavier one under a lighter rainfall. No amount of manuring or of management will secure good crops if the type of soil is not suited to the plant. Thus the Rothamsted wheat plots, even those receiving abnormally large dressings of manure, have only on two occasions (1864 and 1894) given 50 bus., which on a good brick earth would be by no means an exceptional crop, even when grown, as usual in England, with but little manure. To each type of soil there is a limiting yield, beyond which the crop will not go. Attempts to make it by excessive manuring only result in 'laid' crops, while crops of equal or greater size are standing well on the better soils. But the limit is not the same for all varieties; and it is not unusual to find that one variety may do better than another under one set of conditions, but not so well under others. Hence the necessity for the plant-breeder's work.

We are now in a position to describe more fully what constitutes a fertile soil. It must contain sufficient amounts of organic matter, of fairly soluble potassium compounds, phosphates, and calcium carbonate. There must be enough, but not too much, of the finest clay particles, as well as certain proportions of the coarser particles. Exactly what these proportions should be depends on the crop and the rainfall. Some crops, like wheat, can do well on widely different soils; others, like barley, require rather a special type, which, however, varies somewhat with the climate. In estimating the effect of rainfall one general rule holds. The structure of the soil should be such that superfluous water is removed quickly, while a sufficient supply always remains for the plant. In regions of heavy rainfall much less of the finest material is necessary than in regions of moderate rainfall. The position of the soil and the nature of the subsoil are of great importance. These various points are illustrated by the series of typical soils brought together in Table II on p. 52.

§ 47. INDICATIONS OF FERTILITY.—It is possible by mere inspection of the land to form an opinion of its fertility. The native vegetation usually affords a safe index to the character of the soil: preponderance of narrow-leaved plants adapted to small transpiration, such as spurry, heather, conifers, &c., suggest drought conditions; whilst strong-growing, broad-leaved plants, such as burdock and nettles, indicate more favourable water conditions. Spurry, corn marigolds, or foxgloves are a sign that calcium carbonate is absent. Ground ivy is often found on poor rabbit land, silver weed on chalk land. Certain trees, like elms, are found on fertile soils, oak on clays, conifers on sands, alder on wet marshy ground, beech and yew on dry chalk. The local value of the land affords another way of judging its fertility. It may be safely inferred that the land is poor where the roads and lanes are wide, with wide grass strips at the side and high straggling hedges, and where there are a number of commons. On the other hand, narrow roads and lanes and closely kept hedges are found on fertile land. Other indications may hold locally, but are not generally true. In many districts the presence of round, black pebbles would be taken to indicate fertile soil. What they really indicate, however, is a particular geological formation which happens to give rise in those districts to a fertile soil. Elsewhere the same formation may prove much less fertile in spite of its black stones. Under OXIDATION IN SOILS is described a laboratory method of gauging fertility based on the similarity in requirements of plants and of bacteria. Soils suited to the development of bacteria, and therefore showing high bacterial activity, are also well suited to plants.

§ 48. CONDITION.—We have seen that the texture of the soil is largely regulated by its composition, but it is susceptible of a certain amount of change, especially in regard to the condition of the clay. A heavy soil can be made more like a light soil by treatment with lime, by judicious dunging, and by skilful cultivation, all of which processes flocculate the clay; a light soil can be made more retentive by dung, folding, or green manuring. The amount of plant food can also be increased. All soils indeed can be improved by manuring and proper cultivation, or can be deteriorated by bad management. We thus have to distinguish that part of the fertility of the soil which is due to its structure, chemical composition, position, &c., from that which is due to human effort. The former is spoken of as the inherent fertility,

TABLE II.—MECHANICAL AND CHEMICAL ANALYSIS OF TYPICAL SOILS WITH THEIR SUBSOILS
(From The Soils of Kent, Surrey, and Sussex, by A. D. Hall and E. J. Russell)

	Barren Waste.	Fertile Soils. Light, Market-garden Soil.	Fertile Soils. Loam.	Fertile Soils. Strong Loams.	Fertile Soils. Strong Loams.	Fertile Soils. Stiff Fertile Soil.	Grassland. Too heavy to cultivate.
LOCALITY	Sussex, Down Park.	Kent, Swanley.	Kent, Barton.	Kent, Wye.	Sussex, North Chichester.	Surrey, Tolworth.	Kent, Bethersden.
GEOLOGICAL FORMATION	Folkestone Beds.	Thanet Beds.	Thanet Beds.	Brick Earth.	Brick Earth.	London Clay.	Weald Clay.
MECHANICAL COMPOSITION.							
Surface Soils (0 in.–9 in.).							
Fine gravel, above 1 mm. ...	0·88	1·20	0·23	1·04	0·97	0·41	0·89
Coarse sand, 1–0·2 mm. ...	59·74	10·27	2·30	3·07	1·35	12·82	1·52
Fine sand, 0·2–0·04 mm. ...	22·14	58·68	34·71	27·26	16·03	25·54	8·74
Silt, 0·04–0·01 mm.	3·92	13·37	36·23	40·07	35·50	11·30	13·70
Fine silt, 0·01–0·002 mm. ...	3·88	5·10	6·35	8·93	13·39	11·13	31·62
Clay, below 0·002 mm. ...	2·76	5·52	11·58	11·25	15·91	23·75	27·83
Subsoils (9 in.–18 in.).							
Fine gravel, above 1 mm. ...	1·65	0·74	0·04	0·24	0·46	0·55	
Coarse sand, 1–0·2 mm. ...	66·71	10·57	1·24	1·96	0·89	6·72	
Fine sand, 0·2–0·04 mm. ...	20·96	57·47	38·06	25·39	19·38	15·46	
Silt, 0·04–0·01 mm.	2·90	13·97	28·96	41·43	35·85	11·93	
Fine silt, 0·01–0·002 mm. ...	3·93	4·89	7·96	9·68	12·77	12·97	
Clay, below 0·002 mm. ...	1·59	6·08	14·66	14·57	20·13	36·44	
CHEMICAL COMPOSITION.							
Surface Soils (0 in.–9 in.).							
Moisture	1·36	1·24	2·27	1·76	3·32	4·92	4·87
Loss on ignition	6·40	2·95	4·32	5·56	6·58	5·61	9·24
Nitrogen	0·117	0·100	0·140	0·226	0·220	0·241	0·20
Alumina (Al_2O_3)	*nil*	1·70	3·46	3·83	5·50	5·95	8·60
Oxide of iron (Fe_2O_3) ...	2·38	1·70	2·56	2·70	3·05	3·80	6·33*
Oxide of manganese (Mn_3O_4)	*nil*	*nil*	0·02	*nil*	0·06	0·03	0·02
Magnesia (MgO)	0·08	0·23	0·46	0·26	0·40	0·97	0·29
Lime (CaO)	0·13	0·18	0·67	0·42	1·79	1·51	1·19
Carbonates, reckoned as carbonate of lime ($CaCO_3$) ...	*nil*	0·02	0·18	0·18	0·75	2·00	0·84
Potash (K_2O)	0·05	0·217	0·404	0·40	0·43	0·57	0·37
,, soluble in 1-per-cent citric acid	0·010	0·014	0·015	0·040	0·014	0·016	0·011
Phosphoric acid (P_2O_5)	0·064	0·084	0·119	0·282	0·138	0·120	0·176
,, ,, soluble in 1-per-cent citric acid... ...	0·009	0·026	0·048	0·119	0·020	0·019	0·014
Sulphuric acid (SO_3)	0·02	0·03	0·05	0·07	0·06	0·05	0·06
Subsoils (9 in.–18 in.).							
Moisture	0·85	1·19	2·67	2·34	3·21	6·88	
Loss on ignition	2·34	2·94	3·09	3·67	4·94	5·07	
Nitrogen	0·063	0·063	0·088	0·101	0·139	0·097	
Carbonates, reckoned as carbonate of lime ($CaCO_3$) ...	*nil*	0·05	0·03	0·10	0·66	0·52	
Potash (K_2O)	0·067	0·269	0·404	0·43	0·43	0·57	
Phosphoric acid (P_2O_5) ...	0·053	0·057	0·119	0·314	0·138	0·042	

* Much ferrous iron.

the latter as the condition of the soil. Inherent fertility is that for which the farmer pays rent; condition, on the other hand, is the result of his own efforts, and is a matter for compensation when he leaves. No hard-and-fast distinction can be drawn between the two. Instances are numerous where an improvement in condition has led to a permanent increase in fertility. Several of the Rothamsted plots received dung for several years in succession, and were then cropped without manure. There is even now a difference in yield between these and the continuously unmanured plots, as shown by the Table on p. 53. A further illustration is afforded by the heavy chalking of certain clays practised in the 18th century, which effected an improvement not only in condition but also in fertility, still visible at Rothamsted and other places. The varying customs of land valuers in different parts of the country show how impossible it is to draw a sharp line and say where 'condition' due to the tenant's effort ends, and 'inherent' fertility due to the soil begins. The question is best studied by discussing what is meant by soil exhaustion and soil amelioration.

Grassland—Yields of Hay, First and Second Cuts

	Average yield, 1856-63.	1864.	1865.	Average, 10 years, 1866-75.	Average, 10 years, 1876-85.	Average, 10 years, 1886-95.	Average, 10 years, 1896-1905.
	lb.	lb.	lb.	lb.	lb.	lb.	lb
Plot 9—Farmyard manure 1856 to 1863, but no manure since	4800	5390	2850	3730	3750	2790	1940
Plot 3—Unmanured continuously	2660	2690	1300	2370	3020	2620	1690
Difference	2140	2700	1550	1360	730	170	250

Barley Results—Total Produce in lb. per Acre

	Average, 1852-71.	1872.	1873.	1874.	1875.	1876.	Average, 1877-81	Average, 1882-6	Average, 1887-91.	Average, 1892-6.	Average, 1897-1901.	Average, 1902-6.
Plot 7-2.—Dung every year .	5930	5200	6560	7940	5820	6170	6170	6550	5330	6480	5350	6220
Plot 7-1.—Dung 1852-1871, unmanured since	5930	4870	5160	5670	3950	4010	3300	3490	2600	3100	2200	2480
Plot 1-0.—Unmanured continuously .	2450	1280	1570	1920	1450	1560	1530	1530	1380	1510	1140	1300

Soil Exhaustion or Soil Deterioration

§ 49. Broadly speaking, there are four ways in which soil may be caused to deteriorate: (1) it may be cropped without being supplied with proper or sufficient mineral and organic substances; (2) the cultivation may be so bad that the texture of the soil is injured; (3) weeds may be left unchecked; (4) various physical and mechanical causes may do injury.

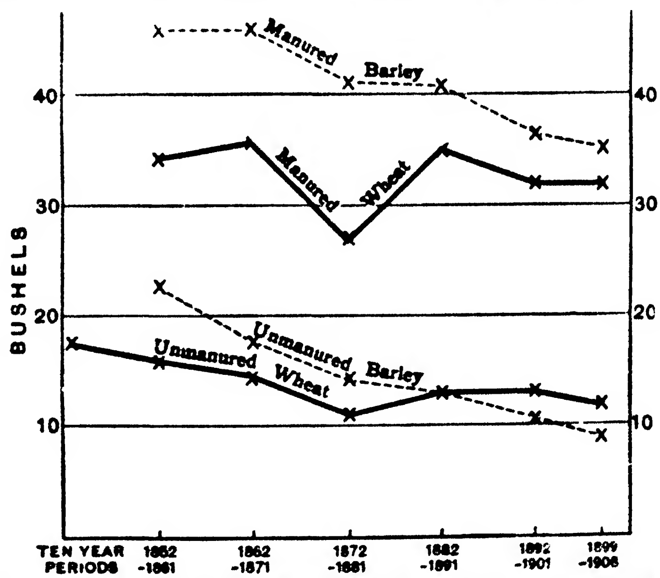


Fig. 5.—Curves showing the fall in the yield of barley and of wheat grown for many years without manure at Rothamsted. The yields on the plots receiving complete artificial manures are also set out (§ 50).

§ 50. *Cropping with no Manure or Improper Manure.*—Both at Rothamsted and at Woburn plots have been cropped without manure for a long number of years, and have furnished valuable data for studying soil exhaustion. For the first few years the crop falls considerably, but then it ceases to fall: this result is shown in the following figures, plotted in fig. 5. Exhaustion on the heavy Rothamsted soil is now very slow, and is indeed practically imperceptible. There is no evidence that the crop will fall any further: 12 bus. probably represents the permanent productiveness of the soil under present conditions of cultivation, climate, &c. Weeds, insects, fungi, &c., may kill the crop altogether, but not soil exhaustion. The Rothamsted soil still contains well over 2000 lb. of nitrogen on the top 9 in., whilst each crop takes

out 15 lb., of which 5 lb. are supplied by rain and seed, leaving only 10 lb. to come from the soil each year; probably some of this is fixed by bacteria from the air.

	Rothamsted: Yield in Bushels.							Stackyard Field, Woburn: Yield in Bushels.	
	8 years, 1844-51	10 years, 1852-61.	10 years, 1862-71	10 years, 1872-81.	10 years, 1882-91.	10 years, 1892-1901.	Last 10 years, 1899-1908.	First 10 years, 1877-86.	Last 10 years, 1899-1908.
Unmanured wheat[1]	17·2	15·9	14·5	10·4	12·6	12·3	11·6	17·4	11·1
Complete artificials[2]	—	34·7	35·9	26·9	35·0	31·8	32·0	32·3	23·4
Unmanured barley	—	22·4	17·5	13·7	12·7	10·0	8·6	26·9	12·6
Complete artificials[3]	—	46·1	46·4	41·0	40·7	36·3	35·1	46·0	33·3

[1] Plot 3, no manure since 1839. [2] Plot 7. [3] Plot 4A.

Exhaustion also goes on when incomplete manures are added, but at a slower rate. The Rothamsted wheat and barley plots receiving only one kind of manure always give higher crops than the unmanured land. Secondary effects may of course set in: nitrate of soda may injure the texture of the soil or sulphate of ammonia may deplete the lime, and then the crop begins to fall more rapidly.

The deterioration in grassland mown without addition of manure is shown not only in the yield but in the character of the herbage. The number of species increases; on the unmanured plot at Rothamsted no fewer than fifty species occur, against about forty on the manured plots. The character of the herbage is shown in the following table:—

Percentage Composition of the Herbage

	Gramineæ.		Leguminosæ.		Other Orders (Weeds).	
	1862.	1908.	1862.	1908.	1862.	1908.
No manure (Plot 3) since 1850 ..	70·6	52·2	8·1	7·8	21·3	40·0
Complete mineral manure (Plot 7)	64·6	41·7	24·7	33 1	10·6	25·1

Pasture soils deteriorate more slowly, especially if they initially contain much soluble mineral matter. The fatting fields of Romney Marsh have fatted sheep for many years past without any manure and with little or no artificial food. The chalk pastures of the South Downs are said to last indefinitely, even when breeding flocks are kept on them. The deterioration of pasture or meadow land due to bad grazing or other mismanagement arises from the effect on the grasses and not the soil.

In natural prairie or wood conditions there is no exhaustion, but an equilibrium. The mineral matters are all returned to the soil, the calcium carbonate is preserved to a considerable extent, and the organic matter and nitrogen undergo little or no change since the gains approximately balance the losses. This equilibrium is, however, disturbed as soon as the conditions are changed.

Continuous cultivation without periodical 'rests' in seeds mixtures tends to exhaust the organic matter of the soil. The vegetation is annually disturbed, and therefore never forms the great root system characteristic of old pastures. The supply of organic matter is cut off, and the stock already present in the soil is oxidized; nitrogen is simultaneously lost (§ 21). In this way prairie soils become exhausted, and the process is accelerated by the custom common among pioneers of burning the straw instead of making it into dung. The losses partly arise from bacterial decomposition and partly from drainage, both of which causes are much accelerated by cultivation. Drainage losses may be reduced by catch cropping or by using well-balanced manures, but bacterial losses cannot be avoided by any known means. So long as nitrogen compounds remain in the soil they are liable to loss. There can be no doubt whatever that the sound practice is *not* to leave the nitrogen compounds in the soil, but to crop them out as completely as possible, and to make the added manure 'exhausting' in this sense. Nitrogen compounds must be replaced, but they should be kept circulating.

§ 51. *Spoiling the Texture of the Soil.*—A proper tilth depends on the maintenance of the clay particles in a flocculated condition, and is therefore damaged by such operations as ploughing the soil when wet, or bringing up unflocculated material of bad texture from below. Much of the ill effect of steam ploughing in early days was brought about in this way. This is perhaps the most serious of all soil injuries, and is only overcome by persistent good management.

§ 52. *Physical or Mechanical Injury to Land without Crop.*—Trouble from this source is not common in the British Islands, where the chief source of loss is the washing out of nitrates (§ 23) and of calcium carbonate. But in subtropical countries, or in newly settled countries, where natural vegetation is being interfered with, serious trouble may arise. The burning of the bush and grass on the South African veldt has destroyed vegetation which used to hold back storm water. It now rushes along the tracks made by cattle or wagons, and causes considerable erosion. The small channels or 'sluits' increase rapidly, and in time

may become rivers. Sixty years ago the Ongers or Brak river in Cape Colony did not exist; to-day its channel is 200 ft. wide and 15 ft. deep. The destruction of forests has the same effect. Similar cases arise in the United States. In many parts of the Mississippi valley the bank on the concave side is being eaten away at the rate of 100 to 150 ft. a year. The remedies suggested in Cape Colony are to dam the sluits at frequent intervals and to plant American aloes, willow trees, pampas grass, and such grasses as will grow. In the southern States of the United States terracing is adopted. Blowing sand is in other places a fruitful source of trouble. In parts of Australia the vegetation has been destroyed either by man or rabbits, and the soil which it had previously held together is now blown about by the wind. In Central Asia great tracts have been devastated. The effect may be seen in a small way in parts of our own country, *e.g.* on the north coast of Cornwall, and also on parts of the coast of Europe from the south of France round to the Baltic; in places the sand advances as much as 25 ft. a year.

In tropical and subtropical countries—West Indies, Malay Peninsula, the southern States of the United States—it is not found desirable to keep orchards, rubber plantations, cotton fields free from vegetation; if the general surface is fallow, as in orchards here, the soil temperature becomes so high that excessive evaporation of water takes place.

Soil Amelioration

§ 53. In order to improve the soil it is necessary first to discover, and then to put out of action, the factor or factors limiting productiveness. The discovery of the limiting factor is a purely scientific problem, but the choice of methods of putting it out of action is a practical and economic problem, since the improvement must pay. To get over the bad effects of soil exhaustion it would seem only necessary to add the proper quantities of the requisite material; but the process is by no means as simple as it looks—indeed it may at once be said that we know no way of carrying it out properly and quickly. It is easy to add, but at present impossible to effect the uniform distribution that is necessary. The difficulty lies in the absorbing power of soils for soluble substances (§ 22). If a soil is deficient in organic matter, the addition of a good deal of dung, of guano, &c., will not at once put matters right. Even the best ploughing, scuffling, &c., only indifferently mixes it in. There remain lumps of excreta which would poison any root that touched them, pieces of straw that will open up the soil and allow loss of water by evaporation, and masses of soil where no dung has yet penetrated. The soluble part of the dung does not get properly distributed by the winter rain; it is held up by the layer of soil nearest to it and gets no farther. Distribution is slowly effected by washing, by earthworms and other organisms, perhaps by micro-organisms; but it is slow, and *we know no way of hastening it.* It is impossible to lay too much stress on this point. Only when the added fertilizers have become properly distributed and intimately mixed in the soil does it get into 'good heart', and the process is so slow that years may elapse before it is completed. When 14 tons of dung were applied each year at Rothamsted to exhausted wheat and barley land, it took about thirteen years before the full effect was produced. A quicker way is to feed crops on the land or to leave for two or three years a seeds mixture or leguminous crop after a previous cleaning. The roots spread themselves throughout the soil much more uniformly than any implement could do it, and give rise, when the crop or stubble is ploughed in, to a mass of easily decomposed material. 'Resting' the ground in this way is a recognized part of many rotations, and is being used with success for recuperating some of the prairie soils of the United States which had been run down by years of continuous wheat growing. The proper minerals should be supplied; in some of the United States experiments, ground rock phosphate was found sufficient. In England another plan has been used on run-down soils: after deep ploughing to bury the weeds, and a good dressing of lime, a root crop is obtained by liberal dressings of artificials, which is then fed on the land. Clover is sown in the subsequent corn crop, and is first folded, then the residues are ploughed in. It is possible by this means to bring the nitrogen content to any desired level between the values for exhausted soils and for old pastures on the particular formation involved.

Improvement in Texture.—Proper cultivation, green manuring, dressings of dung or of lime, and, if necessary, drainage, are suitable methods for improving the texture. See Cultivation, Effect on Soil.

Improvement of the Water Supply.—In districts where there is sufficient rainfall (20 in. or more) the water supply can usually only be increased by improving the subsoil—often a costly and sometimes an impracticable plan. Any pan that may have formed must be broken, or any thin layer of natural rock, such as sometimes occurs in the Lower Greensand of Kent or Surrey, must be removed. A clay subsoil is improved by drainage. Often it may be necessary to divert the underground flow of water by cutting off the line of seepage by means of a trench. Few improvements in British agriculture were more effective than the drainage of the 'forties, although much of it was wrongly done. Drainage is also receiving attention in the United States, where it is estimated that some 70 million acres may yet be reclaimed by this means. Elsewhere trees are planted to take up excess of water; on the Pontine marshes of Italy eucalyptus is grown, and on the Landes of Western France the maritime pine.

Where rainfall is insufficient, recourse has been had from time immemorial to irrigation. It is imperative that a proper drainage should simultaneously be laid down; without this, irrigated lands in all parts of the world have rapidly deteriorated because of the accumulation of alkali at the surface of the soil (see Alkali Soils). The drainage system must be suffi-

ciently deep to prevent the subsoil water rising too high, another source of damage in irrigation. Terracing is an ancient method of irrigation applied where springs break out on the sides of hills well up above the valleys.

Removal of Injurious Substances.—In the absence of calcium carbonate it happens that deleterious substances are formed, particularly if the air supply is limited. They are often acid, and can be neutralized by addition of lime and by improved cultivation.

Liming is beneficial for a great number of soils, and is usually the first step in improving derelict land. It improves the texture, removes acids or other injurious materials, facilitates the production of plant food by bacteria, displaces potassium from some of the zeolitic-like combinations, and is useful in other ways. In the United States it is often said with truth, 'a lime country is a rich country'. Liming was in the past extensively practised, and the present generation in many districts is still benefiting by the old dressings. It is often found rather costly nowadays, and has therefore not been as common as is desirable. To some extent, dressings of basic slag have supplied the necessary lime.

§ 54. How Far can Soil Amelioration Go?—We have already seen that there is a limit below which the crop does not fall, if it is given a chance against weeds, pests, &c., and we conclude that soil exhaustion will not go on indefinitely, but soon comes to a stop. In like manner there is an upper limit beyond which soil amelioration is no longer possible. The limit may be fixed by the rainfall, the temperature, or the type of soil, none of which can be altered very much; finally by the plant itself, which is only capable of a certain amount of growth. The two limits vary for different soils; but between the limits for a particular soil it is possible for a farmer to reach any level he likes, if he considers it worth his while. [E. J. R.]

Soil, Bacteriology of.—It is now a well-recognized fact that the fertility of a soil depends very much upon the number and character of its bacterial population. The reason of this is that bacteria, on account of their physiological activities, bring about the formation of various kinds of soluble nutritive salts that are of immediate use to growing crops. One of the commonest types of soil fermentation is that produced by the numerous forms of decay bacteria acting upon the stores of organic matter present in all fertile soils. As a result of their action, the complex organic molecules are broken up and reduced to simpler compounds. Then there are the characteristic changes due to the activities of nitrifying bacteria and to the free nitrogen-fixing groups of bacteria, the sulphur and iron bacteria, and others. It is only possible in this article to describe very briefly the changes brought about by the more predominant and directly useful races of bacteria.

Ammonification.—All ordinary soils contain a small percentage of organic nitrogen (protein) which is subject to the attacks of putrefactive or decay bacteria. There are several well-known forms, apparently common to all soils, of which *Bacillus mycoides* is perhaps the most prominent. This organism is intensely aerobic, and thrives best at a temperature of 30° C., but grows quite actively at the ordinary summer temperature of soils. Under favouring external conditions (moisture content being an important factor) *Bacillus mycoides* first liquefies and then breaks up the protein compounds into carbonic acid gas and ammonia, together with relatively minute quantities of other bodies (including certain organic acids). At the same time the mineral constituents are released in a form more or less readily available to crops. Acidity of soil tends to check the work of this and other desirable putrefactive germs, so that the presence of lime to establish even a slight alkalinity is helpful. Furthermore, in the presence of an available base the oxidized sulphur of the decomposed protein body gets transformed into a sulphate.

In addition to *B. mycoides* there is quite a number of other more or less well-known bacteria present in the soil, each taking an active part in the work of ammonification. Among these are *Proteus vulgaris*, *Bacillus mesentericus vulgatus*, and *Bacillus subtilis* or the hay bacillus. The supply of air to the soil regulates the intensity of the ammonification process. Light soils are often 'hungry' ones; that is, they contain, naturally, a low percentage of organic matter, and any application of farmyard manure gets used up very rapidly because of the favouring conditions for aerobic fermentation. The other extreme is a very close-grained soil or an undrained soil permanently water-logged. In these cases there is a lack of oxygen, so that the work of fermentation must be carried on by aerobic bacteria. This means that the action will be slower and the end products different. Ammonification indeed is only reached after a series of complicated step-by-step analyses of the complex protein molecules. Peptonization sets in, followed by the breaking up of the molecules into compounds varying very much in character and complexity of composition. Some of the intermediate products are represented by such bodies as peptones, amides, and fatty acids; but the final or end products that are of agricultural interest are ammonia, carbonic acid gas, compounds of sulphur, marsh gas, and free hydrogen and nitrogen. The mineral constituents are left in an insoluble form and are therefore unavailable for crops. Comparing aerobic with anaerobic fermentation, the former is by far the most favourable for cultivated crops. The ammonifying power of a soil is undoubtedly an important factor in its fertility. It depends directly upon the number and vitality of its decay bacteria, and this in turn depends upon the physical and chemical character of the soil. Organic matter must be present in sufficient abundance; there must be moisture, and, for the best kind of fermentation, there must be a sufficiency of air. Applications of lime, farmyard manure, 'artificials', drainage, tillage, system of cropping, and even the micro-fauna—all have their particular influence upon the character and extent of the ammonifying micro-flora.

Nitrification.—The ammonium salts formed in the soil as a result of bacterial action, or the sulphate of ammonia directly applied as a ferti-

lizer, are easily soluble in water, and are therefore readily removed in the drainage. But it is well known that ammonium salts do not exist for long as such in most fertile soils. They readily *change into nitrates. The drainage water from* land manured with sulphate of ammonia will *show this salt for a few days, but after that it will disappear and nitrates be found instead.*

The change, as suggested by Pasteur in 1862, and experimentally proved at a later date by Schloesing and Müntz, is brought about by specific soil organisms that are strongly aerobic, hence they require a well-aerated soil for their development. They differ, however, from the ammonifying bacteria, inasmuch as they not only do not require organic compounds as food, but the presence of the smallest quantity of soluble organic matter in the soil checks or even altogether stops their growth. Nitrification is a two-act process carried on by two distinct kinds of bacteria. The first step is the oxidation of ammonia into nitrous acid, which in the presence of a suitable base (such as lime, magnesia, or potash) immediately forms a *nitrite*, and this in turn is oxidized still further by another species into a *nitrate*. In the absence of a suitable base, the presence of free nitrous acid at the seat of action first checks and then wholly stops the action. These nitro-bacteria obtain their carbon from carbonic acid gas as green plants do, but unlike green plants they can assimilate the carbon in complete darkness. Soils appear to differ very much in their nitrifying power, and such variations influence to no small degree the fertility of our fields and gardens. It has been shown, for example, that soils classed by farmers as 'poor' invariably show a weaker nitrification potential than soils classed as 'good'. Variations in this respect depend upon the physical and chemical character of the soil as well as upon the character of the bacteria themselves, while climate, especially in relation to soil temperature, has considerable influence. The chief soil conditions that influence are, first, the water content. If the soil contains so much that it is approaching a water-logged condition, then air is excluded, and this is obviously fatal to a process that is essentially one of oxidation. On the other hand, if moisture falls below a certain minimum, nitrification stops, and if the soil becomes actually dry the nitrifying organisms quickly die. Acidity of soil is fatal to nitrification. With regard to the bacteria themselves, some strains are more virulent than others, while in all races a certain periodicity of activity is manifested. That is to say, there are periods of intense nitrification preceded and followed by periods of comparative inactivity, the crest of each wave (in all cases where the phenomenon has been followed) being separated by a four or five weeks' interval.

Denitrification.—In soils containing a poor supply of air, nitrates are liable to be destroyed through the fermentative action of a large number of anaerobic bacteria and moulds. They find in the highly oxidized nitrates a source of energy, and as a result of their vital action the nitrates are first reduced to nitrites, and then the nitrites are decomposed with the liberation of elementary nitrogen. The action is called denitrification, and under certain soil conditions the loss of nitrogen in this way may be considerable, but it is nevertheless pretty safe to assume that under good systems of farming there is *little chance of much loss arising from this particular cause.* The mere disappearance of nitrate from the soil may possibly involve little or no loss of nitrogen. For example, the nitrate may be reduced to nitrite only or to ammonia, or it may be used up by certain bacteria as a food and converted into organic nitrogen (or protein). The application of nitrate of soda to soils directly encourages the growth and rapid development of certain races of bacteria, in which case, of course, the nitrate is shared between the bacteria and the standing crop.

Nitrogen Fixation.—There are quite a number of soil organisms now known to have the power of assimilating free or elementary nitrogen from the air. The first of these to be described was a certain butyric ferment isolated by Winogradsky in 1895 and named by him *Clostridium Pastorianum*. It is an anaerobic form, but can work in ordinary tillage soils in association with aerobes, as these sufficiently reduce the oxygen pressure to a point favourable to the Clostridium. If there is no readily available combined nitrogen present, this organism can utilize the simple nitrogen gas of the air to build up its own complex protein molecules. Later (1901-2) Beyerinck discovered two other 'nitrogen fixers' which he named *Azotobacter*. They, however, are aerobic, and can be artificially cultivated in fluids containing very little or even no compounds of nitrogen. Then Lipman in 1903 discovered a third, to which in 1904 he added two others, and so a varied and widely distributed Azotobacter flora is being gradually made known to science. They all require a soluble carbohydrate and the usual inorganic food basis. They are very sensitive to even a slight acidity, hence the presence of lime in the soil is an important factor in their development. There is little doubt that under favourable conditions these organisms considerably enrich the soil with nitrogen compounds.

There are other organisms in the soil that can not only fix the free nitrogen, but can, as opportunity offers, enter into a physiological partnership with specific host plants. The formation of root nodules in the Leguminosæ is the outcome of such symbiotic relations. Discovered first by Hellriegel and Wilfarth in 1886, a soil bacterium, afterwards named by Beyerinck *Bacillus radicicola*, has this important power. The bacillus attacks the younger parts of the roots, gaining an entrance by way of the delicate tubular root-hairs, and, apparently, the poorer the soil in available combined nitrogen the easier the task of entering. The resistance of the plant to the invading and then multiplying bacillus is manifested by the local inflammatory swelling. While actively developing in the nodule they extract from the host-plant sugar and mineral salts, while the host-plant apparently extracts from them in return valuable nitrogen compounds. As growth proceeds, the cells of the nodule get filled with the characteristic short, rodlike (or normal) bacteria; but these after-

wards alter in shape in various ways, until eventually the vast majority of them die, and finally get digested and distributed to different parts of the plant as a rich nitrogenous food. The survivors remain in the partially depleted cells until on the death and decay of the roots they get released and start a fresh life in the soil. All known varieties of this bacterium are very sensitive to even a slight acidity of soil, and until this is corrected no developmental progress can be made. *Nor will they thrive in a soil deficient in phosphorus or potash. Soils that do not naturally contain any particular variety may be inoculated with artificial cultures of the same*, but it is useless to attempt the inoculation of a soil that is either physically or chemically unfit for the growth of these organisms. Furthermore, it is waste of time and trouble to inoculate soil that already contains the germs. For example, it has been demonstrated that so far as ordinary garden soils in these islands are concerned, it is unnecessary to inoculate for peas.

CELLULOSE FERMENTATION.—The research of Omelianski has shown the existence of two types of anaerobic bacteria that reduce cellulose compounds in the soil. In the one case, free hydrogen is one of the end products, and in the other marsh gas. The process of humification appears to be associated with the action of these organisms. The formation of humic substances in the soil is said to hasten the work of the breaking down of mineral matter in the soil.

EFFECT OF TILLAGE AND MANURING.—The actual number of bacteria present in any soil depends upon many factors, and will vary with the class of soil. For example, in woodlands, in gravelly soil, and in stiff clay pastures the number is comparatively low, while in cultivated loams and in garden soils the numbers rise often to several millions per dry gramme of soil. The first 6 in. of soil support a vaster population than the underlying layers, while the subsoil gets poorer and poorer in life the deeper we go. Tillage (under proper conditions of drainage), by breaking up the clod and admitting more air, increases enormously the number of bacteria, while manuring often brings about potent changes in the character and extent of the fermentations. Farmyard manure not only increases the stock of bacteria food, but introduces a vast alien population of active micro-organisms. Lime, as we have already seen, increases ammonification and nitrification, more especially if there is a sufficiency of available phosphorus in the soil; but if lime is used in excess it reduces these actions, and rather favours the process of denitrification. Nitrate of soda, being not only a direct food of many ammonifying bacteria, but of crop plants as well, is extremely helpful all round, especially if applied early in the season before nitrification begins. The application of small dressings of nitrate of soda when green crops are 'ploughed in' has been suggested because of its immediate availability to decay bacteria. Sulphate of ammonia gets changed to carbonate of ammonia in the soil; and as its extensive use causes acidity, this fertilizer tends therefore to retard the work of decay bacteria and encourage the development of moulds. Superphosphate alone seems to somewhat encourage ammonification, but if anything it rather discourages nitrification and nitrogen fixation; while on the other hand basic slag distinctly increases ammonification, apparently because of its contained lime. Pure potash salts appear to have no effect on ammonification, a depressing effect upon denitrification and nitrogen fixation, while to a limited extent they encourage nitrification.

STERILIZATION OF SOILS.—*The partial sterilization of soils either by heat or volatile antiseptics* has been shown to bring about very interesting results, the most obvious of all being a remarkable increase in the crop. The soil flora is made up of a considerable number of competing races, and when a volatile bacterial poison such as carbon bisulphide is introduced into the soil, the immediate effect is to practically suppress all bacterial activity; but as the bisulphide slowly disappears, the ammonifying bacteria are among the first to recover; and having for a time no serious competitors, they feed, grow, and multiply at an abnormally high rate, hence the rapid accumulation of ammonium compounds in the soil and a more liberal supply of nitrogen to the crop. But a still more interesting reason for the increased ammonification in partially sterilized soils has been recently discovered by Drs. Russell and Hutchinson. These two workers find that the soil contains a vast number of protozoa—minute unicellular animals—that ingest bacteria as their natural food. In untreated soil these organisms therefore keep down the number of bacteria, and so control the extent of bacterial fermentation; but the volatile antiseptic not merely inhibits but actually kills the protozoons, so that when the ammonifying bacteria recover they multiply at an amazing rate, seeing that their natural enemies are now destroyed. [D. H.]

Soil, Changes taking place in. See arts. SOIL; SOIL, GEOLOGY OF; FERTILITY.

Soil, Geology of.—The soil is a fragmental rock, derived from the breaking down of other rocks on the earth's surface. Where the materials worn off by disintegrating agents have accumulated in their place of origin, or where they have been drifted to some other and more sheltered spot, they form a deposit of loose structure, into which the roots of plants can make their way. This is the soil known to the primeval agriculturist, who broke it up and turned it over, and raised crops on it for his own use. He thus supplemented the processes of nature, and provided more and more surface on which the agents of decay could act. The plants raised in successive years not only removed certain food supplies from the loose earth, but materially altered its character by adding in due course their own decaying vegetable matter. The salts in the soil, moreover, became changed by the attack of acids, and by oxidation through repeated contact with the atmosphere; the action of various micro-organisms was facilitated; and the soil, after a few years of cultivation, proved to be something more complex and distinctly different from that which first gathered on the surface, before the settle-

ment of man. To the geologist, however, the virgin soil is the first consideration, and it falls to him to trace its various constituents back to their parent rocks.

All rocks, whether sedimentary or igneous, have cracks in them, technically called joints, which may have been produced by shrinkage as the mass consolidated, or by stresses during subsequent earth movements. The subtle agents of disintegration work along these joints; brown oxide of iron forms crusts upon them, showing how iron silicates or carbonates are beginning to give way; in mixed masses, the chemical breaking down of one mineral constituent leaves the rock friable, and a powder gathers in the widening crack. Whole blocks of rock thus become surrounded by crumbling products of their own decay. If the mass possesses good lamination, or a slaty cleavage, the pieces thus worn from it retain a certain flakiness. In such rocks as basalt, on the other hand, where a scaling or exfoliation goes on over the surface of the blocks, spreading inward from the main joints, great unweathered spheroids may appear, set in a powder that appears at first sight to be of an entirely different nature. The roots of plants, reaching far down into this decomposing zone, not only assist decay by wedging apart portions of the rock, but also exert a chemical action. Earthworms, passing the finer material through their bodies, reduce it to a still finer grade, and transfer it in their movements to the upper surface, thus contributing to the growth of soil.

Limestone masses dissolve slowly over their joint-surfaces, and thus become separated into blocks to an extent unknown among other rocks. The detached blocks, roughly rectangular, are found lying in an earth that is partly fine calcareous matter, and partly the insoluble residue from the limestone. In layers nearer the surface, even the limestone blocks may have disappeared; the more impure ones, however, remain represented by porous clayey residues, retaining the original form of the lumps of rock.

In the uppermost zone, the material has become more obviously broken down and more fragmental than in those below. The colour is no longer that of the altered rock, but is darkened by admixture of vegetable matter. Sometimes the brown iron staining, which is so common a sign of alteration, has been lost in the highest zone through the leaching action of waters containing organic acids. This upper zone is the true *soil*. What lies below is *subsoil*; below this again is the parent rock.

But the thickness of the upper zone may vary greatly. The passage from it downward into the subsoil type may, moreover, be absolutely gradual, especially where plants have struck deep roots in search of nourishment. To define the soil, it is convenient to limit the term to the portion reached by ordinary agricultural operations, that is, to the uppermost 8 or 9 in. (say, 1 decimetre) of our section, under the vegetable sod that has probably formed upon the surface. What follows as we sink lower, whether of the same nature or no, is regarded as subsoil, down to the unaltered rock.

In regions where frosts are frequent, these play a great part in the formation of soil, by breaking up lumps of rock which have absorbed water. The surface stones thus become broken down, even where no crumbling through chemical action has been possible.

Sometimes the subsoil is not a true *sedentary soil*, that is, one derived from the underlying rock. The whole mass may be a *transported soil*, or, more accurately, a transported subsoil, which gives rise to a surface soil different from that which otherwise might have gathered in the district. The alluvial infilling of valleys in the British Isles may thus rest on a foundation of rock scoured clear of its proper soil by glacial action. Glacial deposits furnish transported sub-

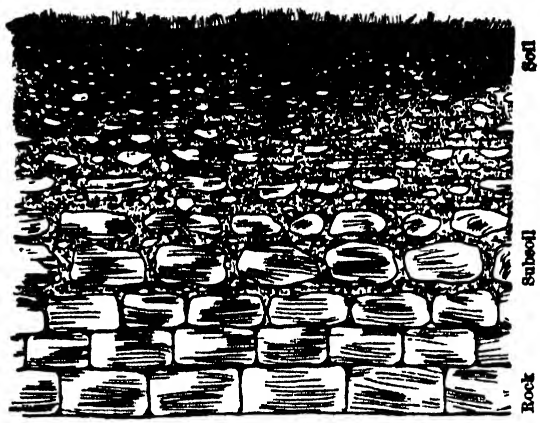


Diagram illustrating relation of a soil to the subsoil, and of the latter to the underlying rock

soils, the soils on which may be a distinct gain to the area in which they arise. Such deposits may be hundreds of feet in thickness, in which case their lower layers may be regarded as the parent rock of the subsoil and the soil.

In some cases, the soil and subsoil may be a thin residue of some deposit that once lay as a mantle over the country, and through it some older bed is likely to appear at intervals. The 'clay with flints' of our chalk downs is now held to be derived from Eocene deposits, and not from the solution of the chalk below it. Here we have a soil and subsoil, sedentary and not transported; but we find nothing left of the more coherent mass from which they were derived by weathering.

The gradual development of a soil may be interestingly studied in regions that have only recently escaped from glacial conditions. In Finland, for example, one may see the ice-rounded surfaces of hard gneiss or granite beginning to pass into something not absolutely smooth, on which lichens can just spread and cling. A little dust from the slowly decaying surface is blown or washed in among the lichens. Through the action of moisture, it becomes compacted into a sort of mould among the recesses of the vegetation, and mosses soon rise over the

lichens and form a rich carpet across the rock. Then come the seeds of trees, birch or pine, caught among the mosses, and tiny shoots spring up, clinging with roots that spread like fingers over the stone. The next step forward to a true forest is a fairly quick one, and a thick vegetable soil accumulates under the trees. But the absence of free evaporation promotes the growth of peat mosses among the underwood, and peat may ultimately develop to a degree inimical to the forest. The trees, now well grown and even aged, decay, and their trunks are added to the vegetable soil. All this accumulation has gone on with the minimum of expenditure of rock material, on a land almost devoid of sedentary soil. In such a country, alluvial valleys, often filled by glacial detritus, provide the only arable land. Large parts of northern Canada, traversed by rushing rivers, have not yet reached a stage when even alluvium can collect. The forest soils may be all there is to deal with, and timber industries take the place of ordinary farming. The variety of soils, of mineral or vegetable origin, is of course enormous; but the blowing of the wind, the downwashing of rain, and the continual spreading action of rivers, tend to produce in a given area a greater uniformity than at first sight might have been expected. [G. A. J. C.]

Soil, Inoculation of. See art. INOCULATION OF SOIL

Soil, Reactions taking place in. See arts. SOIL; NITRIFICATION; DENITRIFICATION; SOIL, BACTERIOLOGY OF; FERTILITY.

Soil, Temperature Relationships of. See art. SOIL.

Soil, Water Relationships of. See arts. SOIL; DRAINAGE.

Soil Analysis.—On arrival at the laboratory the soil is spread out to dry, and is then pounded up with a wooden pestle and passed through a 3-mm. sieve. The stones that do not pass through, and the fine earth that does, are separately weighed, and the proportion of stones to 100 of fine earth is calculated. Subsequent analytical operations are made on the fine earth.

Determination of Moisture.—Four or five grm. of the soil are dried at 100° C. till there is no further change in weight; the loss is called hygroscopic moisture.

Organic Matter.—No accurate method of estimation has yet been devised. It is usual to ignite at low redness the sample dried as above. The loss includes organic matter, water not given off at 100° C., and carbon dioxide from the carbonates; allowance may be made for the latter, but not for the combined water. In more elaborate investigations the carbon may be determined either by the ordinary combustion method or by some 'net combustion' method. Methods have also been devised for determining humus (see HUMUS). For ordinary purposes it is sufficient to determine the loss on ignition, and to speak of this as being largely organic matter.

Total Nitrogen.—Kjeldahl's method is almost invariably adopted. About 25–30 grm. of soil are ground up finely in an iron mortar; 10–15 grm. are then heated in a Kjeldahl flask with 20–25 c.c. of strong sulphuric acid for ¾ hr.; then 5 grm. of potassium sulphate are added, and shortly after a crystal of copper sulphate. The heating is continued till all the black colour has gone. Then cool and dilute the mixture, transfer the fluid part to a distillation flask, but leave as much as possible of the sand behind, washing well to remove all the adhering liquid. Then add saturated soda solution till the liquid is strongly alkaline, distil, and collect the ammonia in standard acid.

Nitrates must be determined in a sample taken direct from the field and dried without any delay at 55° C. 200–500 grm. of the dried soil are pressed firmly on to a Buchner funnel fitted to a filter flask, and distilled water is poured on. The first 100 c.c. of water passing contains practically all the nitrates, but it is safer to wash more fully. The solution is concentrated, acidified with acetic acid, and reduced by a zinc-copper couple at 25° C. for 30 hr. The ammonia formed is estimated in the usual way.

Ammonia is estimated by distilling with magnesia and water under reduced pressure (see Russell, Journ. Agric. Science, 1910, vol. iii).

Carbonates. See CALCIUM COMPOUNDS IN SOIL.

MINERAL SUBSTANCES.—Complete analysis of a soil is only possible after the silicates have been decomposed and the silica volatilized by treatment with hydrofluoric acid. This method is only rarely applied, and details must be looked for in treatises in mineralogical analysis. For agricultural purposes it is sufficient to extract the soil with strong acids. The British method, adopted by the Agricultural Education Association, is thus given by Hall: '20 grm. of the powdered soil are placed in a flask of Jena glass, covered with about 70 c.c. of strong hydrochloric acid, and boiled for a short time over a naked flame to bring it to constant strength. The acid will now contain about 20·2 per cent of pure hydrogen chloride. The flask is loosely stoppered, placed on the water bath, and the contents allowed to digest for about 48 hr. The solution is then cooled, diluted, and filtered. The washed residue is dried and weighed as the material insoluble in acids.

'The solution is made up to 250 c.c., and aliquot portions are taken for the various determinations. The analytical operations are carried out in the usual manner, but special care must be taken to free the solution from silica or organic matter' (The Soil, p. 145).

To determine Potash.—50 c.c. of the solution are evaporated to dryness, *gently* ignited to remove organic matter and render the silica insoluble, taken up with hydrochloric acid, filtered, evaporated, and heated for a time to 105° C., then again dissolved in hydrochloric acid and treated by Tatlock's method. 5 c.c. of a solution of platinum chloride containing ·005 grm. of platinum per c.c. are added, and the mixture *slowly* concentrated on the water bath to a very small bulk. The potassium platinum chloride is filtered off in a Gooch crucible, washed with more platinum chloride and then alcohol, dried, and weighed.

Phosphoric acid is usually determined by Hehner's method, which has also been checked

by Dyer. Starting with 50 c.c. of the solution, exactly the same procedure is followed as for potash, but the final residue is dissolved in nitric instead of hydrochloric acid. After filtering, the solution is treated *in the cold* with excess of ammonium molybdate, the precipitate filtered off, dissolved in ammonia, evaporated, dried, and weighed. It is found most convenient to make the original nitric acid solution up to 50 c.c., to add 5 grm. of ammonium nitrate and 50 c.c. of ammonium molybdate solution containing 60 grm. of molybdic acid per litre, and keep in a warm place for 24 hr.; the precipitate is then filtered off, washed with ammonium nitrate solution, dissolved by ammonia into a weighed basin, evaporated, and gently ignited. The residue contains 3·794 per cent of P_2O_5. A rapid and accurate volumetric method is given in U.S. Division of Chemistry, Bull. 46 (revised), 1898. The molybdate precipitate is dissolved in standard potash, and the excess of potash is titrated with acid.

The iron, aluminium, manganese, calcium, and magnesium are determined in another 50 c.c. by the usual methods; and sulphuric acid is determined in a fourth 50 c.c. Chlorides are best washed out by water; they come out just as readily as nitrates, and the procedure described above under the heading 'Nitrates' is followed. The solution is titrated with silver nitrate, using potassium chromate as indicator.

Available Potash and Phosphoric Acid.—Dyer's directions are as follows: 200 grm. of dry soil are placed in a Winchester quart bottle with 2 litres of distilled water in which are dissolved 20 grm. of pure citric acid. The soil is allowed to remain in contact with the solution at ordinary temperatures for seven days, and is shaken a number of times each day. The solution is then filtered, and 500 c.c. taken for each determination; this is evaporated to dryness, and gently incinerated at a low temperature. The residue is dissolved in hydrochloric acid, evaporated to dryness, redissolved, and filtered; in the filtrate the potash is determined. For the phosphoric acid determination the last solution is made, as before, with nitric acid.

Mechanical Analysis.—The object is to obtain information about the size of the particles of which the soil is composed. The temporary floccules by calcium carbonate or humus are broken down by treatment with hydrochloric acid, and after with ammonia. Direct measurement of the ultimate particles is found to be impracticable; indirect methods have to be adopted, depending on the time taken to fall through a column of water of given height. When a body falls through a vacuum the time taken is independent of the size or weight of the body, but if air or any other fluid is present the time does depend on the size; the proper mathematical relationship has been found by Stokes to be $v = \frac{2ga^2(\sigma - \rho)}{9\eta}$ where v = velocity of the falling particle, σ its density, a its radius (assuming it to be a sphere), and ρ the density and η the coefficient of viscosity of the medium (Trans. Camb. Phil. Soc. 1851, vol. ix, p. 8).

The numerical values at 16° C. are: g = 981, σ = 2·5, ρ = 1, η = ·011, and the equation therefore reduces to $v = a^2 \times 29430$, or $a = \frac{\sqrt{v}}{171}$ cm.

The calculated and observed values are found to agree fairly well, differences being due to the fact that the particles are not in reality spheres, and also to changes of temperature producing convection currents.

The method adopted by the Agricultural Education Association (see Journ. Agric. Science, 1906, i, 470) is as follows:—

1. Ten grm. of the air-dry earth which has passed a 3-mm. sieve are weighed out into a porcelain basin and worked up with 100 c.c. of N/5 hydrochloric acid, the acid being renewed if much calcium carbonate is present. After standing in contact with the acid for one hour, the whole is thrown upon a dried, tared filter and washed until free of acid. The filter and its contents are dried and weighed. The loss represents hygroscopic moisture and material dissolved by the acid.

2. The soil is now washed off the filter with dilute ammoniacal water on to a small sieve of 100 meshes to the linear inch, the portion passing through being collected in a beaker marked at 10, 8·5, and 7·5 cm. respectively from the bottom. The portion which remains upon the sieve is dried and weighed. It is then divided into 'fine gravel' and 'coarse sand' by means of a sieve with round holes of 1 mm. diameter. The portion which does not pass this sieve is the 'fine gravel'. This should be dried and weighed. The difference gives the 'coarse sand'. If required, both these fractions can also be weighed after ignition.

3. The portion which passed the sieve of 100 meshes per linear inch is well worked up with a rubber pestle (made by inserting a glass rod as handle into an inverted rubber stopper), and the beaker filled up to the 8·5-cm. mark and allowed to stand 24 hr. The ammoniacal liquid which contains the 'clay' is then decanted off into a Winchester quart. This operation is repeated as long as any matter remains in suspension for 24 hr. The liquid containing the 'clay' is either evaporated in bulk or measured, and, after being well shaken, an aliquot portion taken and evaporated. In either case the dried residue consists of 'clay' and 'soluble humus'. After ignition the residue gives the 'clay', and the loss on ignition the 'soluble humus'. Here minimum value of $v = \frac{1}{10{,}000}$ cm. per sec., and the minimum diameter of the particles works out to ·0013 mm.

4. The sediment from which the 'clay' has been removed is worked up as before in the beaker, which is filled to the 10-cm. mark and allowed to stand for 100 sec. The operation is repeated till the 'fine sand' settled in 100 sec. is clean, when it is collected, dried, and weighed. Here minimum value of $v = \frac{1}{10}$ per sec.; the calculated minimum diameter = ·037 mm.

5. The turbid liquid poured off from the 'fine sand' is collected in a Winchester quart, or other suitable vessel, allowed to settle, and

the clear liquid syphoned or decanted off. The sediment is then washed into the marked beaker and made up to the 7·5-cm. mark. After stirring, it is allowed to settle for 12½ min., and the liquid decanted off. The operation is then repeated as before till all the sediment sinks in 12½ min., leaving the liquid quite clear. The sediment obtained is the 'silt', which is dried and weighed as usual. The liquid contains the 'fine silt', which, when it has settled down, can be separated by decanting off the clear liquid, and dried and weighed.

For silt, minimum value of $v = \frac{1}{100}$ cm. per sec., minimum diameter of particle = ·012 mm. For fine silt the diameter obviously lies between this value and the one found for clay.

6. Determinations are made of the 'moisture' and 'loss on ignition' of another 10 grm. of the air-dry earth. The sum of the weights of the fractions after ignition + loss on ignition + moisture + material dissolved in weak acid should approximate to 10 grm.

7. It is advisable to make a control determination of the 'fine gravel' in a portion of 50 grm. of the air-dry earth. The soil should be treated with acid, as in (1), and after that is removed by decantation, may be at once treated with dilute ammonia and washed on the sieve with 1-mm. round holes. The 'fine gravel' left on the sieve is then dried and weighed.

The calculated result obviously only holds for those particles which take the full time to fall through the column. There are always some falling in a shorter time, and having, therefore, a larger diameter. The limiting diameters are as follows:—

Name.	Diameter in mm. Maximum.	Minimum.
Separated by sifting—		
Stones	—	25
Small stones	25	10
Gravel	10	3
Fine gravel	3	1
Coarse sand	1	·2
Separated by subsidence—		
Fine sand	·20	·04
Silt	·04	·01
Fine silt	·01	·002
Clay	·002	—

It is unfortunate that no simple way of expressing the results has yet been devised.

The American method is somewhat different. The breaking down of the aggregates is brought about by physical means—*e.g.* violent shaking—and sedimentation is sometimes hastened by a centrifugal apparatus. Hilgard does not adopt a sedimentation method, but proceeds on the converse manner: he collects and weighs the particles carried off by successive streams of water of varying velocity. Full details are given in Bull. 24, Bureau of Soils, 1904, and in Wiley's Agricultural Analysis, vol. i, where the Continental methods are also described.

Interpretation of Soil Analysis. See FERTILITY and SOILS. [R. J. R.]

Soiling System.—The soiling system may be regarded as one which is adapted to the feeding of cattle, and especially of dairy cattle, on a farm which is under arable cultivation and where there is little or no grass. It is desirable to have some pasture, but there are instances where there is practically no grassland at all, where the cows are kept in the whole of the year, except when they are turned out for exercise and drink, and fed upon food which is placed for their consumption in their mangers. This food from spring to autumn consists of green crops usually cut the day before they are employed, in order that a portion of the moisture may be removed by drying in the sun and air. There is no more dangerous plan in feeding cows than to give them a large supply of wet or highly succulent food of the type of vetches, lucerne, sainfoin, or clover, hence the importance of cutting at least twenty-four hours before they are required, and allowing them to wilt.

There is a variety of plants suited to British farms which may be employed with advantage in the soiling system, which is now conducted entirely in cowsheds in the suburbs of large towns. We refer in chief to lucerne, sainfoin, a mixture of clover and ryegrass, ryegrass alone, meadow grass, vetches, *Trifolium incarnatum* (crimson clover), trefoil, maize, green rye, cabbage, ensilage, and rape. All these crops cannot be grown in every part of the British Islands, but a selection should be made suitable to the locality. Feeding stock on the soiling system demands great care and forethought on the part of the grower. It is essential for him to look well ahead and to provide unfailing crops, without which the feeding would prove a costly process, between spring and autumn in every year. Rye is one of the first crops to come into use. This may be followed in the south of England by crimson clover. Vetches follow almost immediately after, while cabbage may be almost continuously planted during open weather, so that it may be held, as it were, as a crop on which to fall back in case of the failure of other plants. Cows thrive well upon the best white-heart cabbage, but when receiving this in large quantities they should be provided with a food such as cotton-seed meal or cake, bean or pea meal, with the object of checking the too free action of the cabbage. We have not referred to parsnips and carrots, both of which, like mangels and swedes, are better adapted for winter use, chiefly owing to the fact that they are more difficult to keep, or rather to depend upon keeping through the summer season. Both carrots and parsnips are highly relished by stock, owing to their sweetness and their appetizing flavour.

In conducting the soiling system it is absolutely essential, if the best results are to be obtained, to add something in the form of grain or meal to the green ration of the cow or whatever stock is fed upon it. For example, foods like lucerne, clover, sainfoin, or vetches, all of which are of a highly nutritious character, should be supplemented by meal which is rich in carbon, such as maize meal, rice meal, or locust-bean meal. Barley meal, rye meal, or wheat meal may also be employed with great advan-

tage, although wheat meal should stand last of all, owing to its greater richness in albuminoids. On the other hand, foods like carrots, parsnips, mangels, swedes and potatoes, green maize, green rye, and English ryegrass, may be better used in conjunction with a nitrogenous cake or meal, such as decorticated cotton cake, or linseed cake mixed with cotton cake, rape cake, pea or bean meal, all of which are rich in nitrogen. To these we may add malt combs, which are also rich in the same constituent, and desiccated grains which have been well soaked in water for at least twenty-four hours before employment. Sweet ensilage is also well adapted for the soiling system, but care should be taken that it is sweet, and not a foul-smelling, sour food, which, whatever its feeding properties may be, is ill adapted for use in connection with the milk supplied, milk taking up its odour and its flavour if it is brought into close contact with this most disagreeable food. [J. Lo.]

Soil in Relation to Plants. See arts. SOIL; PLANTS, NATURE AND FUNCTIONS OF; SOIL ANALYSIS; FERTILITY; CULTIVATION, CHEMICAL AND PHYSICAL EFFECTS OF.

Soil Maps.—Soil mapping was encouraged at an early date; but the necessity for appreciating the underlying structure of a country led to the formation, in the opening years of scientific geology, of 'geognostic' and geological maps, from which the superficial deposits were omitted. The great features of the world had to be first delineated, according to their rock constitution and geological age; and river alluvium, peat bogs, and the taluses of extensive landslides, were almost the only unconsolidated materials set down upon the earlier maps of official surveys. In 1871, the Geological Survey of the United Kingdom issued 'drift editions' of the geological maps of the London Basin; and the practice of publishing 'drift maps' in addition to those showing 'solid geology' has since been regularly continued. These maps meet to a large extent the requirements of the agriculturist, since they represent at any rate the true subsoils. On a 'solid' map, while river alluvium and bog may be, by a somewhat illogical convention, represented by special colours, boulder clays or ancient gravels, even if 100 ft. thick, are omitted, so as to show the underlying 'rock'. On a 'drift map', on the other hand, a great variety of superficial deposits may be shown, and notes are sometimes added as to the characteristic soils formed from them. Reference to the offices of the Government surveys will enable an agriculturist to obtain still further details from the original maps on the scale of 6 in. to 1 mile.

It is clear, however, that a drift map is not strictly a soil map. Where, for instance, 'Sands and Gravels' are mapped together, as a particular type of drift (see art. DRIFT), no account is taken of the relative fineness of the materials in the surface soil. On a valley side, the amount of fine material washed down may cause a wet loam to accumulate at the foot, while a coarse gravel is left higher on the slope. In other cases, a mingling of two or more types of drift may occur in the soil, and the agriculturist will find a greater uniformity of character throughout the area than he would be led to infer from the drift map set before him.

This difficulty can be met by mapping the boundaries of the types of soil, these types being founded on a consideration of their physical and some of their chemical characters. At the same time the nature of the subsoil may be indicated, by a stippling or by any other mode of shading which shall show through the colour adopted for the type of soil. Or a drift map may be constructed, on which signs may be drawn where soil samples have been collected, these signs indicating the nature of the soil, and even the depth to which material of the same general character extends. On the margin of either type of map, small vertical sections (or 'profiles') may be drawn, showing whether the soil type remains continuous to a depth of 3 ft. or whether a subsoil of another nature may be expected within that distance from the surface.

In the United States, a separate soil survey has been organized by the Bureau of Soils of the Department of Agriculture, while the Geological Survey is controlled by another Department. Mr. Whitney, Chief of the Bureau of Soils, has defined his methods of work in his Circular No. 13 (Feb., 1904). He states that in the past 'many soil maps had been prepared, but they were based upon the geology of the area and were of little or no use to the farmer. . . . The Division of Soils . . . believed that a classification of soils with reference to texture and structure, physiographic position, and crop values could be made and the areas of different soils outlined in colors on maps, and that this would enable a farmer or a prospective purchaser of land in the area to determine at a glance the quality and farming value of any tract of land.' Types of soil are established by the United States Soil Bureau for each area undertaken, the character of the crops or native vegetation being taken into account. Where the crops or native plants, as in Florida, vary greatly without any marked difference in the characters of the soil, the botanical aspect must be taken as the main factor in soil classification. The name given to a soil to express its physical texture—clay, loam, sandy loam, &c.—is based on its average character to a depth of 24 to 30 in. Local place-names are attached to the types, but these are used also in other areas where the soil types prove to be similar. Thus, in the portion of an American soil map here selected as an illustration (fig. 1), the Triassic stony loam (now called Penn stony loam) is a 'rather heavy Indian-red loam, 8 to 10 in. deep, containing from 30 to 60 per cent of red and brown sandstone fragments. The subsoil is of much the same character to a great depth.' The Suffield clay is a 'clay loam, 12 in. deep, underlain by close-textured laminated clay. Very poorly drained;' and so on. The scale of the American soil maps is 1:62,500, very slightly over 1 in. to 1 mile, and 'local variations in the character of the soil of less than one-fourth of a mile in extent are generally ignored, unless this variation constitutes a very prominent fea-

ture'. Such maps appear to be nearly akin to the drift maps of geological surveyors.

The maps of the Prussian and Japanese Geological Surveys are virtually drift maps with numerous soil indications marked upon them. The Prussian work (fig. 2) is done on the Government map on a scale of 1 to 25,000 (close on 2½ in. to 1 mile), and the information scattered over the surface and in the margins seems to render the map suitable for the agriculturist, though the boundaries defined are those of the subsoils rather than of precise types of soil.

It is, indeed, still an open question whether general soil maps are required over large areas of country already occupied. In such cases, it would seem more desirable to work at the problems of special districts, and to map the soils in question on a really large scale. The Geological Survey of Ireland now adds soil indications at selected spots on its drift maps on the

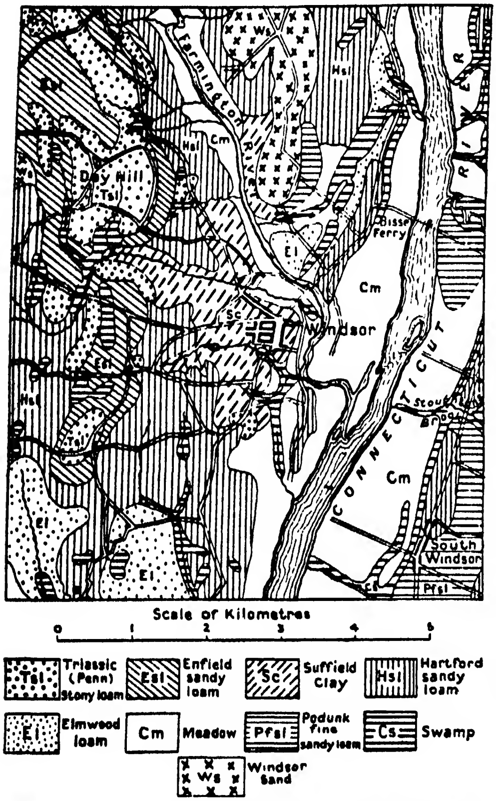


Fig. 1.—Portion of soil-map by the United States Bureau of Soils; the original is colour-printed, the colours being here represented in black and white (Hartford Sheet, Conn. and Mass., 1899). Contour-lines are shown in the original.

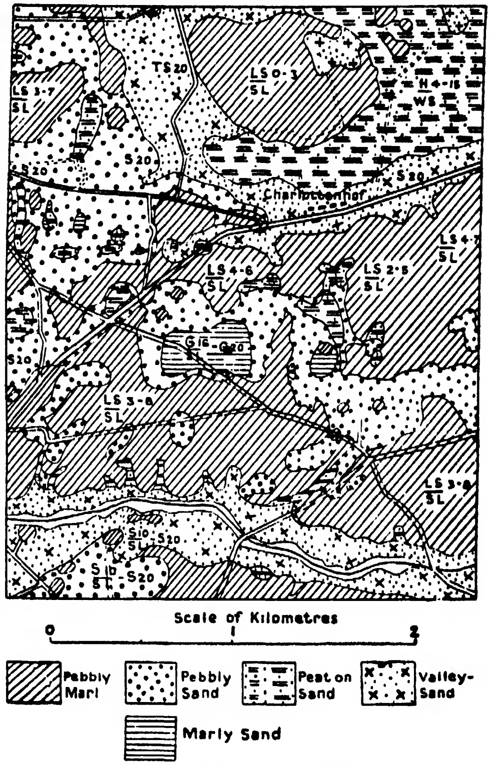


Fig. 2.—Portion of map by the Prussian Geological Survey (Grundabteilung 13, Blatt 55, 1906). The original is colour-printed, with the soil-indications in red. The lettering indicates the nature of soil and subsoil, with depth of the former in decimetres; full explanations are given in the margins of the map.

scale of 1 in. to 1 mile; but its soil maps, with the drift also shown, are prepared only in response to special requirements, and on the scale of 12 in. to 1 mile (close on 1 to 5300).

[G. A. J. C.]

Soil Sampling.—It is obviously of the first importance that a soil sample should be secured which is thoroughly representative of the type of land to be examined, whether that examination is to be conducted on chemical, physical, or biological lines. The selection of the points on the ground at which to collect the samples is often a matter of some difficulty, and depends a good deal on the purpose for which the latter are required.

For example, if it is proposed to make a soil map of a district, the surveyor must, in his selection, be guided by such considerations as the surface features of the ground, and by any striking differences in the character of its vegetation. If a good drift map of the district, on a large scale, is available, it will be found to be of the greatest assistance in obviating the unnecessary multiplication of samples drawn from one and the same kind of 'drift', and the subsequent loss of time on the analysis of what would be practically duplicate earths. Even when only the soils of a small area have to be examined, a knowledge of the geology of its superficial deposits will help the observer considerably. It is important to remember that in the selection of a point for the collection of a soil sample, the neighbourhood of trees, fences, paths, and ditches should be avoided; and it is likewise

desirable, when there is a choice, to take the sample from pasture rather than from tillage land. When the object is merely to ascertain the chemical characteristics of a small plot of land, as a guide to its cultural value, it is usual to take a composite sample by selecting, at intervals all over the plot, several points which do not apparently differ from the surrounding ground; after shaving off the turf and removing dead leaves and other debris not properly belonging to the soil itself, a uniform section consisting of several pounds of earth is dug from each of the chosen points. Then these soil masses are thoroughly mixed together, and from the mixture a quantity of earth is taken which should represent the average soil of the area under consideration.

The collection of an 'individual', that is a single sample from one spot, rather than a composite one representing the average soil of a large area, possesses the advantage that a definite volume of the soil under field conditions can be obtained. This method of sampling readily provides one of the data requisite for calculating the actual pore space of the natural earth.

At Rothamsted, soil samples are collected by means of a steel box without top or bottom, 9 in. deep, and measuring 6 in. by 6 in. in cross section; the lower open end possesses sharp cutting edges, and the upper end is blunted to receive the blows of a wooden rammer. The box is driven into the soil until its top rim is level with the surface of the ground; the surrounding soil is then dug away, and the earth in the box is carefully transferred to a bag, in which it is taken to the laboratory. Two or three samples from the same field, collected in a similar way, are mixed together in order to obtain a fair average soil of the area to be examined. The subsoils to any desired depth are sampled in an exactly similar manner.

The following sampler has been adopted at the Royal College of Science for Ireland and also by the Geological Survey of Ireland. A rigid steel box (fig. 1), having an internal

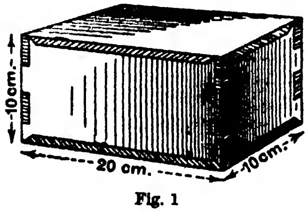


Fig. 1

capacity of 2 litres and measuring internally 20 × 10 × 10 cm., is used for taking the samples. This box is open at two opposite 20 × 10 cm. sides, but is provided with two suitable lids, and the rims at one open side are made chisel-shaped, so that the box may be easily driven into the soil, while the opposite rims are blunt to receive the blows of a hammer or maul. A hole is dug into the ground at the spot at which the soil is to be collected, and one of its walls is cut and smoothed so as to present a plane perpendicular face. A large block of the unbroken soil behind the latter surface is then loosened and lifted bodily out of the hole with a spade, and laid flat on the ground so that the smooth surface is upwards. The box frame is now driven, with a maul, into the soil mass, a short side of the box being placed parallel to the original soil surface just below the turf, and in this way a sample representative of the upper 2 decimetres (nearly 8 in.) of the soil is secured. The material projecting over the rim of the box is cut away and a lid is put on; the soil and box are then turned over, the soil pro-

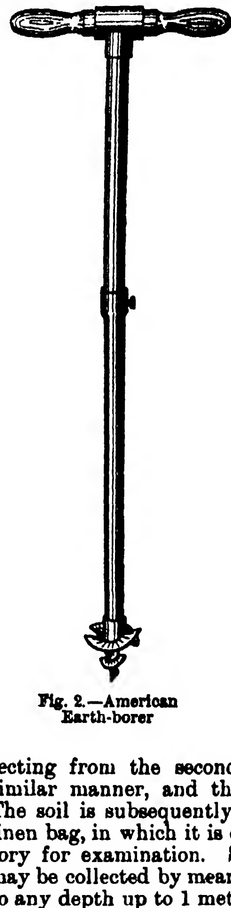


Fig. 2.—American Earth-borer

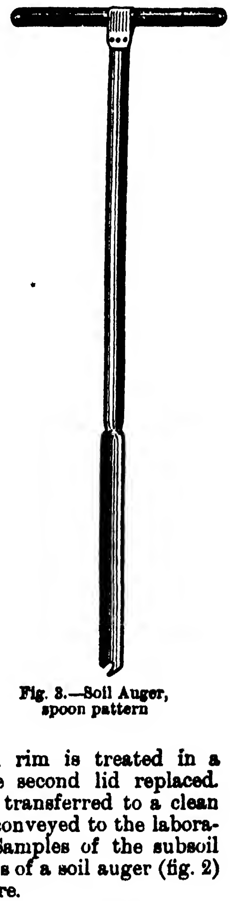


Fig. 3.—Soil Auger, spoon pattern

jecting from the second rim is treated in a similar manner, and the second lid replaced. The soil is subsequently transferred to a clean linen bag, in which it is conveyed to the laboratory for examination. Samples of the subsoil may be collected by means of a soil auger (fig. 2) to any depth up to 1 metre.

As the stones in a soil are not uniformly distributed throughout the entire mass of the latter, there is obviously great danger of introducing a serious error into any calculations which are based on the results obtained from the examination of a single sample, especially when that sample is small. Hence some soil physicists determine the proportion of stones in larger quantities of earth than are usually collected for analytical purposes.

For rapid soil-traverses, samples may be conveniently and expeditiously collected by means of any of the different forms of soil auger that have been devised for that purpose. The one already referred to, known as the American

earth-borer, is very useful for sampling at depths up to 1 metre. Another form of soil auger, the spoon pattern, is shown in fig. 3. Unfortunately these tools cannot be employed on soils containing a large proportion of stones.

Fraenkel's earth-borer, shown in fig. 4, is much used in collecting soil samples for bacteriological investigation; it possesses the advantage that it enables one to collect a soil sample at any given depth, unmixed with any of the earth of the overlying layers. This form of auger consists essentially of a pointed steel rod hollowed near its lower extremity into a cylindrical chamber, open at the side, but capable of being completely closed by a sliding lid attached to a projecting flange and operated by the latter. In collecting a sample, the aperture of the cylinder is covered by the lid, the auger then driven into the soil to the desired depth, and when the latter is reached the instrument is rotated towards the right; this movement first uncovers the opening of the cylinder, and as the auger is further rotated in the same direction the flange scoops into the cylindrical hollow of the rod a sample of the surrounding earth. Finally, after having turned it a little in the opposite direction to replace the lid, the auger containing the sample is withdrawn. An excellent sampling tool has also been devised by Nowacki and Borchardt (see Nowacki, Praktische Bodenkunde, 4th ed., p. 34). [T. H.]

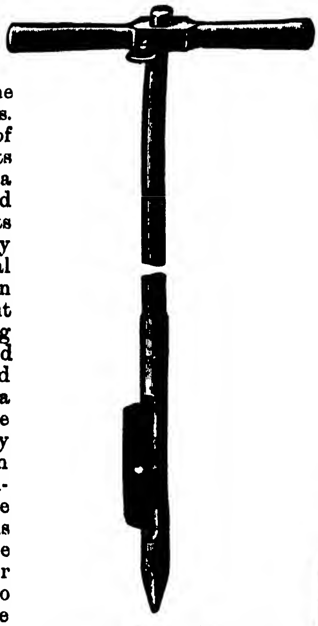


Fig 4.—Fraenkel's Earth-borer

Solidago virgaurea (Golden Rod) is a yellow-flowered composite plant common in Britain in thickets and on sea-cliffs. The shoots spring up from a stout perennial rootstock; they are erect and rodlike, sometimes 2 ft. high, but on sea-cliffs they become dwarfed and are then only a few inches high. The leaves are narrow and lanceolate, from 1 to 4 in. long. The plant is in flower from July to September. The golden-yellow flower-heads are small, ¼ in. in diameter, and are crowded on the ends of the shoots. Each head is composed of 10 to 12 ray florets and 10 to 20 disk florets. The fruit is a ribbed downy cylinder crowned with white rigid hairs (*pappus*). Many species of Solidago are cultivated in shrubberies. [A. N. M'A.]

Solid-hoofed Pigs, an American breed of swine which within recent years has been registered as a pure breed. It is said to be prolific, quick in growth, strongly prepotent, and suitable either for pork-packing or bacon-curing. It is also claimed that this breed is in great measure immune from swine fever; and if this claim can be substantiated, it should render it specially valuable in the United States, where hog cholera is so rampant. The name is derived from the peculiar form of the hoof, a characteristic which is transmitted by all boars of this breed to their progeny when mated with sows of other breeds. [S. S.]

Solomon's Seal. See art. POLYGONATUM.

Sombrerite, a concretionary guano containing fragments of bone, which is associated with phosphatized coral limestone in the island of Sombrero in the Windward Islands. It is excavated as a mineral phosphate, the nitrogenous matter having been washed out of it. It contains about 31 per cent of phosphoric anhydride (P_2O_5). [G. A. J. C.]

Song Thrush (*Turdus musicus*).—This resident songster, with its brown back and speckled breast, is too well known to need detailed description. The bulk of the food consists of insects, worms, snails, and slugs, diligent search being made under plants as well as in open spaces. When a snail is secured it is held firmly in the beak and battered on a stone until its soft contents can be extracted. Wild and cultivated fruits also form a part of the diet. The bird is of great benefit to agriculture, and destroys innumerable pests, but the fruit grower is justified in keeping its numbers down. The cup-shaped nest is commonly found in a tree, 4 to 6 ft. from the ground, but is also often built in a hedge, or among evergreens, and at times, though rarely, on the ground. It is constructed of vegetable fibre and moss, plastered inside with rotten wood, cow dung, and clay. The four or five eggs are greenish-blue in colour, with dark spots. Two or three broods are reared during the season, the first being hatched out late in March. [J. R. A. D.]

Soot has long been used and is highly esteemed as a manure. It is composed principally of charcoal, but it derives its fertilizing properties mostly from the small quantities of ammonium salts it contains. It is obtained in the combustion of coal and wood, the components of which are largely made up of carbon, along with small amounts of nitrogen, sulphur, and other substances. When coal is burnt in a fireplace the greater part of the carbon burns away to carbonic acid gas; some, however, remains unburnt and passes up the chimney in the form of minute particles, as smoke. The soot accumulating in chimneys is formed by the deposition of these microscopic specks of charcoal. Lampblack is the purest form of charcoal, soot being impure charcoal. The nitrogen in the coal is evolved mostly as ammonia, the sulphur as sulphurous acid; this latter substance fixes the ammonia as a salt. Part of the ammonium salts are retained in the soot along with some phosphates, potash, and other mineral substances, which in a fine state of division have been conveyed along with the smoke. Soot

contains about 3 per cent of nitrogen; the amount, however, is variable, and depends a good deal upon the proportion of dirt and cinder admixed with the soot. Cinder contains no nitrogen; if, therefore, much of this substance is present, the percentage of nitrogen present in the soot would be considerably reduced, and its value lowered. When it can be purchased at a reasonable price, farmers would do well to avail themselves of its use; but, in purchasing, care should be taken that the article is genuine and does not contain excessive amounts of mineral matter. The most satisfactory way to purchase would be upon its chemical analysis, when its manurial constituents would be paid for according to their current market values. It is used on grassland, as topdressings for straw crops, and as a manure for green crops. It is highly valued as a manure for market-garden crops, where it is also of value as a slug destroyer. It makes the soil darker, and thus may assist in warming light-coloured soils by absorbing more of the sun's heat. [R. A. B.]

Sorgho (*Sorghum vulgare*, Pers., order Gramineæ), Imphee, Broom Corn, Chinese Sugarcane, &c., are the names most often used to denote particular races of Kaffir Corn, when these are specially grown in order that the stems may be utilized as sources of sugar, or the strong, much branched, and rigid panicles sold as natural brooms. It would seem likely that these approximate most closely to the wild plant *Sorghum halepense*. Popularly the sugar-sorghos belong to the form often spoken of as *S. saccharatum* by many writers. It is largely cultivated in the North-western States of America as a source of molasses and syrup. After the grains have fallen or been removed the panicles harden, and are specially traded in all over the world, being used as whisks or worked up into various forms of brushes. It cannot be said that the degree of success has been attained, with the sugar-sorghos, that was at one time confidently entertained. This result is, however, perhaps more a consequence of the great prosperity of the beet-sugar industry (in modern times) than due to any failure to produce sugar, of considerable merit, from the plants in question. See art. KAFFIR CORN, also MILLETS. [G. W.]

Sorrel is the name applied to certain plants belonging, like a Dock, to the genus Rumex, and to the nat. ord. Polygonaceæ. The leaves of Sorrel are smaller than those of Dock and have a strong acid taste, due to the presence of acid oxalates. The construction of the flower is also different. In Dock only one kind of flower is produced, but in Sorrel two kinds; a Dock flower is perfect with stamen and pistil, whereas a Sorrel makes one kind of flower with stamens only, and a second kind with pistil only. This pistil-containing flower is entirely devoted to the production of seed.

Two species are common weeds, namely, Sheep's Sorrel (*Rumex Acetosella*) and Common Sorrel or Sourock (*Rumex Acetosa*).

Sheep's Sorrel thrives best on poor sandy or gravelly soils deficient in lime. Underground, the plant forms a stem which creeps horizontally and branches extensively. From this perennial structure the air shoots arise. In poor land these shoots are quite diminutive, only 3 in. high, but as the land becomes richer the shoots also lengthen and become 1 ft. high. The leaf-blades are very characteristic, for at the base of each blade there is a pair of pointed ears *spread outwards*, and to mark this feature the special term *hastate* is applied to the Sorrel leaf. The shoots are in flower from May to July, and at this stage it is easy to distinguish the male plant, with the stamens conspicuous, and the female plant, with three crimson-coloured feather-like stigmas projecting from the apex of each flower. From July onwards, the 'seeds' mature; the ovary of the pistil becomes a glossy reddish-brown three-faced nut, pointed at both ends, blunt along the edges, scarcely $\frac{1}{24}$ in. long and almost as broad, not across the middle, but near one end. This nut, called 'seed', is closely invested by a husk of persisting flower leaves.

The seed of Sheep's Sorrel is a common impurity in commercial grass and clover seeds, accordingly the sowing of such impure seed should be carefully avoided. Liming at the rate of 1 or 2 tons per acre, or judicious manuring to enrich the land, mitigates the nuisance. Sheep browse the plant, and depasturing with sheep for two or three years prevents somewhat the spread by seed.

Common Sorrel or Sourock is no creeper; instead, it produces tufts of shoots from the apex of a taproot, and thus becomes a tufted perennial. The shoots are 1 to 2 ft. high, and flower at the same time as Sheep's Sorrel. The leaf-blades are 3 to 6 in. long, and eared like Sheep's Sorrel, but in this case the ears *slope downwards*, and to mark this feature of the leaf-blade the term 'arrow-shaped' or *sagittate* is applied. There are usually male and female plants, the males making pollen, and the females producing seed. This three-faced seed is glossy and dark-brown, $\frac{1}{12}$ in. long, $\frac{1}{20}$ in. broad, and sharp on the edges; it is accordingly easy to distinguish from that of Sheep's Sorrel.

In pastures and meadows, on moist, rich soils containing iron, Common Sorrel is a prevalent weed. For extermination, the plant should be cut down early, since flowering begins in May. Lime applications tend to check its growth. Combined cutting, liming, and judicious manuring to encourage useful plants, will ultimately lead to extermination. [A. N. M'A.]

Souming and Rouming is, in Scots Law, the name for an action whereby parties entitled to a servitude right to pasturage over a common are entitled to have the right settled rateably amongst them. The word 'soum' denotes a quantity of grass which would pasture, according to some authorities, ten sheep or one cow, according to others five sheep or one cow, and in one case the Court held it to be equivalent to what would pasture one cow with a calf until a year old. The custom of the locality to a large extent regulates the standard, which will vary with the quality of the land in different districts. 'Roum' is an old word denoting a piece of land. The effect of the action is to ascertain the amount of stock which the servi-

ent tenement (*i.e.* the common) can pasture, and thereafter to determine the proportion thereof belonging to each of the dominant tenements (*i.e.* the properties owned by the respective commoners), fixed according to their respective capacity for winter foddering; the number of beasts to be admitted to the pasture being proportionate to the number which the various properties can fodder in the winter. [D. B.]

Soundness in Animals. See arts. SALE; UNSOUNDNESS.

Sourness in Land.—The decomposition of organic matter in normal soils sufficiently provided with calcium carbonate does not tend to make the soil acid. It is true that some acids may be formed which react with the calcium carbonate, but the compounds readily decompose with re-formation of calcium carbonate. But if calcium carbonate is entirely absent from the soil, some acid is formed which in the absence of a base is not neutralized, and which does not readily wash out of the soil by rain. The ordinary bacterial flora does not survive, and a new flora, in which moulds play a distinct part, comes in. Such land is said to be sour.

Soils may also become acid through long-continued use of sulphate of ammonia as manure without any dressing of lime. The disadvantages of acid are numerous: (1) bacteria work less efficiently in an acid soil, and consequently produce less humus and nitrates than might be expected; (2) many agricultural crops and good grasses will not tolerate acid surroundings; (3) certain plant disease germs flourish in acid soils. For all these reasons it is desirable to get rid of acid. The method of treatment is, apply lime at the rate of 10 cwt. or more per acre, or chalk at four times the above rate. Where neither chalk nor lime is available it has been found that dressings of finely-ground mineral phosphates are useful, not so much to neutralize the acid as to enable the plant to resist its effect. Basic slag is even more suitable, since it contains free lime, and is therefore capable of neutralizing acids.

Some plants, *e.g.* barley, swedes, sainfoin, and most Leguminosæ, are very intolerant of acids; some, like oats, alsike, rhubarb, will stand more. Others will tolerate a good deal, *e.g.* sorrel, broom, cotton grass. These latter are a safe indication of the presence of acid in the soil.

The term 'sour land' is sometimes, but incorrectly, used for land containing excess of soluble matter; this is discussed under ALKALI SOILS. [E. J. R.]

South Africa, Agriculture of.—The term British *South* Africa is one which is somewhat loosely applied; it is usually understood to mean the British possessions in Africa south of the Zambesi, but sometimes the whole of Rhodesia, portions of which extend considerably north of the river, are included.

According to the latter definition, which is the one adopted in this article, South Africa consists of four self-governing colonies, *i.e.* Cape Colony, Transvaal, Orange River Colony, and Natal—now under a central government and forming the Union of South Africa—of Rhodesia, and of the Protectorates Bechuanaland, Basutoland, Nyasaland, and Swaziland.

The total area, which is still very sparsely populated, is about one-third the size of the Continent of Europe. The total population of white persons of European descent amounts to about 1,135,000, and of native and coloured persons under 10,000,000.

Owing to the extent of country and the complexity of the subject, it will not be possible to do more within the scope of this article than to give a brief and very general description of the agriculture of the sub-continent, and of the system of farming now in vogue.

Though there are naturally many, and sometimes striking, variations of scenery, soil, and climate to be found in South Africa, yet on the whole it is a country of vast, uniform areas, and its live stock, and crops, and methods of agriculture are also similar.

Further, though certain portions of the Cape Colony and Natal have been settled for some time, and specialized forms of farming, such as grape-growing and fruit-farming in the western province, ostrich-farming in the south and east of Cape Colony, and tropical farming and wattle-growing in Natal, have arisen; and though the style of farming practised in the Karoo naturally differs from that in vogue in the High Veld, and yet other methods are followed in the subtropical and more northerly parts; still, the people have moved about so freely and constantly, that the variations of soil and climate generally have not had the same opportunity of influencing and moulding them, and of modifying their practice, that they have had in more settled countries; consequently the farmers themselves, and their live stock and methods of farming, are much alike throughout the whole of the sub-continent.

PHYSICAL FEATURES. — The physical geography of South Africa is comparatively simple, for the sub-continent falls naturally into three well-defined areas. The first, or coastal, comprises a strip of land running round the coast from the Cape to the Zambesi, and varying in width from a few miles at the south to 60 or 70 miles farther north. On the landward side of this piece of low-lying ground, and also, of course, running roughly parallel to the ocean, is a series of ranges of mountains of which the loftiest is known as the Drakensberg; and these mountains, together with their foothills on the one side and sundry subsidiary ranges and broken ground on the other side, constitute the second; whilst a vast plateau occupying the whole of the interior forms the third.

The Drakensberg mountains vary in altitude from 7000 ft. to 12,000 ft., while the central plateau varies in altitude from 2500 ft. to 6000 ft.; it is highest along its eastern side, from whence it slopes gently towards the west. On some parts of the plateau there are series of ridges and mountains, and on others depressions like the Karoo; but in the main the country consists of a series of plains, in some places almost flat, in others gently undulating.

CLIMATE, RAINFALL, &c.—A noteworthy and regrettable feature of South African geography is the scarcity of water; beyond a few 'pans' there are no lakes or sheets of water, and the

rivers and streams are few in number, and so rapid in flow and varying in volume that they are useless for navigation.

As a rule the climate of South Africa is dry, rather windy, and exceedingly exhilarating; it is also remarkable for its large amount of sunshine and cloudless skies. Along the south coast from Cape Agulhas, the most southerly point of the continent, eastwards to East London, a narrow strip of country has a rainfall fairly distributed over the twelve months of the year, and sufficient in quantity for the general purposes of agriculture. The south-west corner of the continent, which includes the district around Cape Town, has a winter rainfall; that is, during May to September, as the seasons are changed in the southern hemisphere. Going northwards from Cape Town along the coast, the rainfall diminishes very rapidly. From Port Nolloth northwards to Walfisch Bay the climate is one of the most rainless in the world. Leaving this arid region and travelling inwards brings us to the westward limit of the summer rains.

Over the rest of the sub-continent, and therefore over by far the larger part of it, the greater part of the rainfall occurs during the summer months, October to April, with January as the average wettest month; the winter months being practically rainless.

The summer rains are heaviest along the east and south-east coasts, and decrease both in quantity and number of rainy days as one travels inwards to the west; but even on the western border of the Transvaal the average rainfall amounts to 22 to 26 in. (equal to the average mean of London).

The summer rains usually occur during thunderstorms, and are sometimes accompanied by hail, which at times is very destructive; cyclonic rainstorms also take place in summer, and are often accompanied by heavy rainfall. Unfortunately, in some seasons these cyclonic rains fail, and when they do there is apt to be a drought or a partial drought, as the only precipitation which then takes place is that due to thunderstorms, which are notoriously uncertain.

As previously stated, the total rainfall is usually good, and would be ample for agricultural purposes were it suitably distributed; but that is not always the case, for sometimes the rains are late in commencing, to the serious embarrassment of owners of live stock, who are anxious for fresh grass for their animals, and to the curtailment of the growing period of the crops. Again, instead of the steady soaking rains and the frequent wet days met with in some countries, a certain amount of the rain is apt to fall in a succession of light showers, only to be immediately evaporated; and a still greater proportion of it in torrential downpours, also unsatisfactory, since much of the water runs off the ground instead of entering it. Further, and more trying still, it often happens, even in the most rain-favoured parts of South Africa, that long periods—perhaps two or three months—elapse without any useful rains.

The annual average temperature is about 60° to 65° F. These figures cover an enormous area as the altitude of the interior above sea level moderates the temperature otherwise due to its latitude. The range of temperatures is small along the coasts, and frosts are unknown; but over the interior night frosts during the dry winter months are very frequent, especially in valleys over the Cape peninsula and on the lowlands. In other parts of South Africa the summer temperatures sometimes reach 100°, but when this occurs the air is so dry that little discomfort is caused. As a rule, no matter how hot the day, the nights are cool and refreshing; and though in the warmer portions of the country the summers may be a little trying, yet the winters are delightful.

Geology, Soils, &c.—The geological history of South Africa, as far as it relates to agriculture, is very different from that of Northern Europe and America.

South Africa is geologically old, and it lacks the newer deposits, and it has had no recent glacial period. As a general rule its soils vary strictly in accordance with the nature of the underlying formations, for they are derived directly from them; soils of alluvial origin occur locally, but the association of certain soils with particular rocks and formations is the rule in South Africa.

Speaking generally, and of course with many and sometimes noteworthy exceptions, the soils of South Africa are thin rather than deep; and as a rule there is not such a marked difference between soil and subsoil as is found in many parts of Europe and America, nor are they so stiff or retentive as many of the clays and loams of those countries.

The prevailing soils are sandy loams of varying shades of red or chocolate, but there are also large tracts of a darker and heavier soil known locally as black turf (resembling the 'adobe' of California), and in some of the valleys and certain other places there are alluvial soils of great depth and richness, whilst in depressions upon the surface are to be found dark 'peaty' or 'vlei' soils.

When wet but not too wet, in the case of turf and vlei ground, the soils are not difficult to work; they are open in texture and fairly friable, and a seedbed is easily prepared; but, curiously enough, when dry, all, except the lightest of them, become exceedingly firm—so hard, in fact, that a traction engine passing over them would make scarcely any impression.

With the exception of black turf and vlei soils, humus does not accumulate in the soils to the extent it does in the more temperate regions. Judged by European standards, the soils are not rich; but owing to the amount of light and warmth, and to their open texture, what plant food there is in them is readily available, and given a sufficiency of water the growth of crops is rapid and abundant. They are 'grateful' soils, and respond readily to manures.

Farming Past and Present.—For various reasons of climate and history, agricultural progress in South Africa has been very slow, and farming was for long carried on in a very primitive manner.

There being no sale for agricultural produce except in the vicinity of the ports, and the keeping of live stock being easier and more in conformity with the inclination of the farmers as well as more profitable than the cultivation of the ground, their attention was mainly devoted to it. In the first instance they were simply nomadic pastoralists and graziers in common; but as the interior became more fully occupied, it was gradually apportioned into farms. The farms were large, and more like ranches than farms, the average size being about 7000 ac., and in some parts, such as the Karoo, considerably more. It was customary for a farmer to have two farms—one situated in the High Veld, which was particularly good for stock in summer, and the other in the Low Veld, where grazing and shelter could be obtained in the winter.

When selecting a farm the chief considerations were an adequate supply of water, freedom from diseases and poisonous plants, good grazing, shelter, and, if possible, a piece of ground capable and worthy of being irrigated. Because of its scarcity and of the marvellous results obtained from irrigated ground, water was, and still is, greatly prized. The water supply and the land that can be irrigated are *the* features of the farm, and water rights have ever formed one of the chief sources of dispute amongst farmers.

As a rule the farms were demarcated by landmarks or beacons, and as a rule entirely unfenced. The buildings consisted of a dwelling-house, a rough stable, and the inevitable kraals, *i.e.* yards, commonly made of stone walls some 6 or 7 ft. high, or of stout thorn bushes, and without any covering of any kind for protecting the cattle at night from beasts of prey. Failing a perennial stream, there was usually a dam or reservoir fed by an intermittent stream, or a spring to provide water for the stock and, where possible, to irrigate a piece of arable ground. Agricultural implements were simple, and consisted of little more than a wagon and trek gear, a plough and harrow, together with Kaffir hoes, sickles, and a few tools like axes and so forth, and perhaps a Cape cart. The labour was all performed by natives, who, in return for the privilege of living upon the farm and having a little ground to cultivate, and grazing for a few head of stock, had to work a certain number of days each year for the farmer; if wages were paid at all, they were very small and mostly in kind.

The cultivation of the crops was conducted in the simplest and easiest manner possible. The crops were sown broadcast; there were no subsequent cultivations; the crops on dry land were left alone until ripe, and those on irrigable ground were watered as required. The mealies and Kaffir corn were harvested by removing the ears or heads, which were shelled or threshed by hand, and the wheat and similar crops were cut with a sickle; the grain was threshed on a threshing floor by oxen and winnowed by the wind, just as in Biblical times.

This was the state of affairs prior to the discovery of gold; but since that period the whole aspect of affairs has altered, and a great change has come over agriculture in common with other things. At first progress was slow, but in recent years it has proceeded more rapidly, and marked advances have been made in every direction.

In addition to hail and drought and other climatic troubles, insect and fungoid diseases are common. *Locusts* are perhaps the worst pests that vex the South African farmer, but, thanks to the action of the Governments of the various colonies in taking concerted action to destroy them, it seems likely the danger from them will be greatly minimized in the future, if not entirely overcome. Other pests are yielding to treatment also, and owing to the action of the Governments the outlook as regards the control of all and the extirpation of some is hopeful.

The Veld.—In its natural state, practically the whole of South Africa, with the exception of some rocky and mountainous portions, is covered with vegetation—sometimes thickly, and at other times but scantily. In the higher and better-watered parts of the country the grass is fairly close and comparatively short; in the Bush country it is usually thick, and sometimes high and coarse. In the more arid and sandy or rocky regions the grass gives way to dwarf bushes called Karoo bush, edible by stock, and various succulent plants. The grasses are mostly 'bunch' or 'tuft' grasses, and do not form a turf such as one finds in Europe. According as the grasses are coarse and strong or thin and wiry, resinous and bitter or sweet, or short and succulent, the veld is distinguished as 'sour' or 'sweet'. In order to get rid of the long coarse grass and to provide green food for the stock, the practice of burning the veld at certain seasons of the year has arisen; and the making of fire-lines in autumn round the borders of a farm is essential to its safety.

Chief Crops.—Most European grasses and clovers do not do well in South Africa; but curiously enough the veld does not suffer from breaking up in the same way as old pastures do in Europe, and when left alone it soon re-establishes itself; immediately after ploughing, and for a few years longer, the land is remarkably free from weeds, but after that they rapidly accumulate. When the grass becomes thoroughly dry, as it does in the High Veld during winter, it seems to lose the whole of its feeding value and to become quite innutritious. Of late years the practice of cutting the veld for hay, and of growing special crops for that purpose, has become more common. An undesirable feature of the veld is the presence of poisonous plants in certain districts at certain seasons of the year, and frequently heavy losses are occasioned by stock grazing thereon.

Maize, or 'mealies' as it is commonly called in South Africa, is the staple crop of the country. It is easier and cheaper to cultivate than any other crop, and is hardy and rust-resistant, and therefore capable of being grown during the summer—the natural growing season. It is the chief food used by the natives, and is also largely consumed by white people, particularly the older residents. Maize can be grown wherever the rainfall exceeds 20 in., and it thrives

best in districts that have a good rainfall during January and February.

The crop takes from 100 to 180 days to grow and ripen, according to the variety and season, and the average yield is about 3 bags of 200 lb. net per acre on the poor uplands to 6 bags on the richer alluvial soils. The crop responds readily to cultivation and manuring, and yields of 20 bags per acre are frequently obtained on good land well treated, whilst as much as 35 bags have been obtained in exceptional cases.

The Cango, Botman, Bread or Flour Mealie, and Kaffir varieties were practically the only ones grown in South Africa until the introduction of Hickory King and Horse-tooth into Natal; the last two have spread over South Africa, and are now cultivated more extensively than any other kinds. In recent years several new varieties—some of them of considerable promise—have been introduced.

The best South African maize is equal if not superior to any in the world; and it has already obtained a high reputation in the European markets for quality and condition, as it is so well grown, and contains from 4 to 5 per cent less moisture than ordinary commercial samples.

Maize is a decidedly remunerative crop at present prices, and, as they appear likely to continue, there should be a bright future before maize growing in South Africa; provided the facilities afforded for export are maintained, and the Governments are careful to grade the maize properly, and the farmers to grow only the best sorts, keep them pure, and cultivate them well.

Hitherto maize has been chiefly regarded as a food for human consumption, and very little of it, or indeed of any artificial food—except oat hay and green barley—has been fed to live stock; but methods are changing rapidly, and it may safely be predicted that, before long, maize will be used for ordinary farm stock, and for fattening steers and pigs, as is done in other parts of the world.

Kaffir Corn (*Sorghum vulgare*) is, next to maize, the crop most extensively grown in South Africa. It is chiefly cultivated by natives, who use it for food and for brewing beer. Like mealies, it is a summer crop, and is hardy and easy to cultivate. It yields somewhat heavier than maize, but the cost of harvesting is a little more; and the protection of the crop from birds, which are intensely fond of it, is difficult and expensive, except in districts where there are abundance of natives.

In addition to Kaffir corn, several other kinds of millet, such as the ordinary Boer manna and Indian millet (both varieties of *Setaria italica*) and Japanese millet (a variety of *Panicum crus-galli*), are largely grown during the summer for hay and forage.

Wheat.—Unfortunately, this crop, like many of the other cereals, is very susceptible to rust during the summer, consequently its growth is more or less restricted to the south-western portions of Cape Colony, the eastern part of the Orange River Colony, and parts of Basutoland, where it can be grown upon dry land during the winter without irrigation, and elsewhere to such land as can be irrigated. Several varieties of wheat, mostly local, are grown, and others are being tested.

The yields obtained are good, often amounting to from 30 to 40 bus. per acre, and on exceptionally rich or well-manured land even more; and, if properly grown and harvested, the quality is excellent.

The supply is still far below local requirements, and the imports of wheat and wheaten flour into South Africa amount to something like £1,600,000 in value per annum.

Rust is the great obstacle to the cultivation of wheat, oats, barley, and several other crops in South Africa. Some varieties of them are not quite so susceptible as others, and can be grown in summer with some success, but by no means all, and even the best are uncertain.

Oats, as already remarked, suffer like wheat from rust, and for that reason, with the exception of the varieties known as Algerian and Sidonian, which are moderately resistant, they have to be grown during the winter; in a few parts of South Africa they can be grown at that season of the year without irrigation, but that is exceptional, and they usually need water.

In Cape Colony it has recently become the practice to grow oats for grain, and in 1909 a fair quantity was exported. The usual method of treating oats is to cut them a little before the grain becomes ripe, and to tie them in small bundles or sheaves weighing from 2½ to 5 lb. each; this is known as oat hay or forage, and, cut into chaff, or fed whole, it is the common food of horses and mules in the stable or on trek, and of milch cows when stabled. A local variety, known as the Boer oat, is admirably suited for this purpose, as it has a short fine straw and large spreading head.

The weight of oat hay per acre varies from 1500 lb to 3000 lb., and it realizes from 5*s.* to 9*s.* per 100 lb. on the market. In the olden days the hay was invariably sold by the 100 bundles, but now it is becoming customary to sell it by weight, and, for the more progressive farmers, to press it into bales instead of making it into small and uneconomical bundles.

Barley.—Promising samples of brewing barley have been grown experimentally, but at present prices the crop is not as profitable as wheat, and the risks from insect and fungoid diseases and of damage from rain when harvesting are greater. Local brewers import most of their malting barley, but they are testing the six-rowed Cape barley (*Hordeum hexastichon*) grown in the Cape Colony and in the Orange River Colony. Some excellent barley of the Chevalier and Goldthorp types has been grown at the Experimental Farm, Potchefstroom. Cape barley is hardy and shrubby in habit and quick growing, and is widely cultivated on irrigated land in the colder districts as a forage crop, as it produces a welcome supply of green food when most wanted, *i.e.* during midwinter.

MISCELLANEOUS CROPS.—The European horse-bean does not do well in South Africa, and Soy Beans (*Glycine hispida*) are more promising for regions of summer rainfall, though some difficulty has been experienced in getting this crop to thrive, perhaps for lack of the requisite [illegible]

bacteria. The Chick-pea or gram (*Cicer arietinum*) and Pigeon Peas or Dhol (*Cajanus indicus*) are satisfactory as summer crops in the warmer parts of the country.

Rye, Nepaul Barley (Barley-wheat or *Hordeum trifurcatum*), Buckwheat, and Linseed are also grown to a limited extent for grain or for forage as the case may be.

Lucerne is, *par excellence*, the perennial hay crop where irrigation can be practised; it can also be grown with a fair amount of success on dry land, provided the rainfall is good; in either case the soil should be deep, rich, and well-drained, and such areas are limited in number and extent. On good land under water an average of 2000 lb. of dry hay per cutting is usual, and six cuttings per season are frequently obtained. In recent years prime Lucerne hay has been selling for from £5 to £8 per ton of 2000 lb. Lucerne is greatly prized in Cape Colony as a food for ostriches both for grazing and feeding as hay, and in favoured districts, like Oudtshoorn, enormous sums of money are paid for land suitable for growing it for that purpose.

A variety of grass introduced by the Transvaal Department of Agriculture from Abyssinia and known as Teff (*Eragrostis Abyssinica*) has proved most useful as a hay crop, and is now being largely cultivated in the Transvaal.

In addition to the crops already mentioned, Cow Pea (*Vigna catjang*), Kaffir Beans (*Vigna catjang* var.), Velvet Beans (*Mucuna utilis*), Teosinte (*Euchlæna mexicana* var. *luxurians*), and several other crops are being experimented with for the making of ensilage.

Root Crops. — Of the root crops, mangel wurzel is the most satisfactory. Swedes, white turnips, and kohlrabi do not do particularly well except in the cooler, moister parts of the country. Cabbages of various kinds can be grown, and prove very useful at times. Sugar beet does well in various parts of the country, but for several reasons, mostly economic, it has not yet been found possible to establish factories for the conversion of it into sugar.

Potatoes are grown extensively, especially for the Johannesburg market, where they usually command a good price. With skilful management and water it is possible to grow two crops a year; without water only one crop can be obtained. Most of the European varieties succeed in South Africa, but, owing perhaps to the rapidity with which they grow, and to their not ripening very thoroughly, the potatoes do not keep so well as they do in Europe. The crop which ripens during the summer keeps for a very short time, whether raised or not; the crop which ripens in the autumn, just as the dry weather sets in, will keep sound and fresh for much longer if allowed to remain in the ground, but not otherwise. Probably, for the same reason, *i.e.* imperfect ripening, or it may be from the varieties not being really suited to the country, or because the plant itself is not really at home, it is said to be difficult to obtain good seed locally; and the bulk of the potatoes grown in South Africa are from seed imported from Europe, which naturally adds enormously to the expense of the crop, and acts as a heavy drain upon the country. As regards size and quality, the tubers compare very favourably with those produced elsewhere.

In the warmer parts of the country the Sweet Potato (*Ipomœa Batata*) and on tropical areas the Cassava (*Manihot palmata* var. *Aipi*) thrive admirably.

Pumpkins, another favourite South African vegetable, grow freely and to an enormous size, and if thoroughly ripe, keep for a long time.

Tobacco, Sugar Cane, Tea, and Coffee.— *Tobacco* has always been a popular crop with the Boers, and a small patch of it is grown on most farms in the warmer parts of the country. The northern slopes of the Magaliesberg range in the Transvaal, particularly in the Rustenburg district, produce a pipe tobacco which has become widely famed. Until lately tobacco has only been grown for local consumption and for pipe smoking. The ordinary 'Boer' or 'Transvaal' tobacco is described as a coarse bastard variety, originally of Sumatran origin, but now much mixed with other varieties that have been introduced from time to time and allowed to cross with local tobacco. Its nicotine content is lower than in most tobaccos, and it burns readily; its aroma is not pleasant, and it possesses a peculiar flavour, but it is light, and can be smoked all day without affecting the head or burning the tongue. People often do not like the tobacco at first, but after they have got accustomed to it they become as fond of it as the older residents are, and, like them, will smoke no other.

Since the war, efforts have been made by private individuals and by the Governments of the various colonies to improve and extend the tobacco industry and to establish an export trade, and there is good ground for hoping that a sound and profitable tobacco industry may be established in South Africa before long.

Sugar cane is the principal product of the coastal region of Natal, and is also cultivated in Zululand; though it does well in those districts, it is somewhat exacting as to its requirements, and outside certain areas it is not likely that it will be much grown in South Africa.

Tea is also successfully grown in the lower and warmer parts of Natal, but as with sugar cane, and for the same reasons, its cultivation is not likely to become very extensive.

Coffee was formerly grown in Natal and in the tropical and subtropical parts of the Transvaal, but unfortunately the coffee disease (*Hemillia vastatrix*) broke out and rendered the cultivation of the crop impossible.

Fibre Plants. — Cotton, Ramie (*Boehmeria nivea*), Sisal (*Agave rigida* var. *sisalana*), Phormium (*Phormium tenax*), Hemp, Jute, Broom Corn (*Sorghum technicum*), as well as various native fibre plants, are being experimented with in different parts of the country. Excellent samples of cotton have been produced, and it is quite probable that in the warmer regions the growing of it and of some of the other fibres may be considerably extended. Both oil seeds and nitrogenous food for cattle are required in Africa, and the cotton seed should prove useful for these purposes.

OIL-BEARING PLANTS.—Peanuts (*Arachis hypogæa*) grow well in the Middle and Low Veld. Like cotton seed they yield a valuable oil, and the residue makes an excellent cattle food. As at present cultivated they are expensive to harvest, but if the cost of this operation can be reduced by the use of machinery, as seems probable, the crop should be extensively grown. The alternation of peanuts with maize is said to form a good rotation.

Castor Oil (*Ricinus communis*) produces one of the best lubricating oils known. The plant grows wild in abundance in the subtropical parts of the country; but the expense of picking is a heavy item, and so far it has been found more profitable to produce other crops than it, though it is quite possible that some day it may be grown on a considerable scale in districts free from frost and well supplied with native labour.

In addition to the above, several other oil and fibre plants, and plants for miscellaneous purposes, such as calabashes for pipes (*Lagenaria vulgaris* var.), loofas or vegetable sponges (*Luffa ægyptiaca*), bird seeds (*Panicum miliaceum*), everlasting flowers (*Helichrysum vestitum*), and many other plants are being tested or grown on a small scale; in fact, South Africa possesses such a variety of soil and climate that there are but few crops that cannot be grown in one part or another of it.

FRUITS, &c.—Owing to the diversity of soil and climate, almost every kind of fruit can be grown.

Viticulture and the making of wine and brandy was established in the western districts of Cape Colony, which have a winter rainfall and dry summer, in the early days of settlement, and forms the main industry of that district. The grapes flourish exceedingly, and a well-kept Cape wine farm is a beautiful sight.

In addition to grapes, the western province, through the foresight and enterprise of the late Mr. Cecil Rhodes, has become an important centre for the growth of apples, pears, plums, peaches, and nectarines, as well as oranges and lemons; and that district now exports large quantities of fruit to Europe which find a ready sale there.

In Natal the growth of tropical and subtropical fruits, such as bananas, pineapples, papaws, Avocado pears, mangoes, and citrus fruits, is carried on to a considerable extent, and citrus fruits and pineapples are exported in large quantities.

The orange is the chief South African fruit; it requires a fairly deep and well-drained soil, with water and a frostless climate. The eastern province of Cape Colony is well advanced in the culture of citrus fruits and produces the greatest quantity, but its culture, as indeed the culture of all kinds of fruits, is increasing all over the sub-continent. During the last few years citrus fruit has been sent to London, where it has been greatly appreciated.

As with other kinds of farming, fruit-growing has its drawbacks, the chief being the liability of the fruit to be damaged by excessive rains just as it is ripening, and by hailstorms, which in some districts are very persistent and destructive. Insect and fungoid diseases are also bad at times.

TIMBER.—Africa south of the Zambesi is a very poorly wooded country. Large stretches of it, like the Karoo, the Orange River Colony, and the High Veld of the Transvaal and Natal, are treeless, except along the rivers and watercourses. There are two main types of forest—the dense evergreen forests and the open scrub forests. The former are confined to the regions of the highest rainfall, viz. the coastal belt from Cape Town to Natal and Zululand, and the seaward slopes of inland mountain chains, such as the Amatolas and the Drakensberg. The number of species of trees found in the forests is large, but the timber of only about a dozen kinds is generally worked. Some species like the Yellowwood reach lofty proportions, trees of over 100 ft. in height being not uncommon. Most do not, however, reach much more than from 60 to 80 ft.

Stinkwood (*Ocotea bullata*) is the most valuable timber produced, and the demand much exceeds the supply. It is highly prized for the manufacture of furniture and wagons.

Yellowwood (*Podocarpus elongata* and *P. thunbergii*) forms the bulk of the wood turned out from the forests, and is, after being creosoted, utilized for railway sleepers.

The other principal species are chiefly wagonwoods. The only wood exported is Boxwood (*Gonioma Kamassi*). The total area of these forests is not much more than 1000 sq. miles.

The scrub forests are more extensive, and occupy large areas in Cape Colony, Natal, the Transvaal, and Rhodesia. The trees composing them do not reach a great height, anything from 15 to 40 ft., according to soil and climatic conditions. They do not form close canopy, and grass grows freely in between them. Farms on which this class of forest is found are highly esteemed by stock-breeders for grazing.

Various species of acacias are the largest element in these forests, which, generally speaking, produce but little timber of any technical value. Fuel, fencing poles, and pit props comprise the bulk of the output.

From the above it will be seen South Africa is practically dependent for its wood on imported timber. During the year 1907–8 the value of manufactured and unmanufactured timber brought into the country reached the large total of £555,181, and as the country develops this total will naturally increase.

In view of this, and of the fact that many exotic trees grow well, each South African Government has undertaken some afforestation. The Cape Colony acted as pioneer, and more recently Natal, the Orange River Colony, and the Transvaal have vigorously followed its good example. At the Cape there are now over 30,000 ac. of plantations, and in the Transvaal about 3000. Eucalypts from Australia and pines from South Europe and California are the kinds most extensively planted.

It would not do to conclude this note without referring to the wonderful forest industry that has been built up in Natal by private enterprise. Twenty-five years ago a small start was

made in planting the exotic Tan Bark Wattle (*Acacia decurrens* var. *mollis*); now there are nearly 200,000 ac. under this crop, and the value of bark exported in 1907 was £136,000. This striking result is unique, and unparalleled in the history of forestry.

WILD ANIMALS.—The quantity and variety of great game which originally inhabited South Africa, and the number of cattle possessed by the natives, furnishes the best possible proof of the suitability of the country for live stock. Within the memory of men now living, the country was tenanted by vast numbers of elephants, rhinoceroses, hippopotami, buffaloes, wildebeest, hartebeest, elands, and other antelopes too numerous to mention, as well as giraffes, quaggas, zebras, wart hogs, bush pigs, and ostriches; the amount of smaller animal life was equally large, and amongst and upon the mass lived beasts, birds, and reptiles of prey—lions, leopards, jackals, wild dogs, crocodiles, and eagles.

LIVE STOCK.—Of domestic breeds of cattle the native breeds were active, hardy, and thrifty, and, what is very important, were resistant to or tolerant of the majority of the enzootic diseases with which the country abounds, but in many particulars they fell short of modern ideas of what domestic animals should be, and in some approximated very nearly to their wild relatives in the veld.

The problem that confronts stock farmers in South Africa—and it is a great and pressing one—is how to produce breeds of stock adapted to the country, reasonably hardy and economical to keep, and such as will satisfy the requirements of the public to whom they or their products will be disposed of; that is to say, horses suitable for draught purposes, or remounts for the army; cattle that will provide as large a proportion of prime beef to their live weight at as early an age as possible, or a large supply of rich milk; sheep which will yield neat joints of mutton or heavy fleeces of fine wool; pigs that will supply prime bacon and hams; and so forth.

The necessity for improving the quality of the stock has been recognized by the more enlightened farmers for some time, and a tendency to obtain better animals is increasingly manifest, and in Merino sheep and ostriches, particularly, great strides have been made.

But South Africa is at a serious disadvantage at present, as compared with the United States of America, Canada, Australia, the Argentine, and other great stock countries, in the danger and difficulty that is incurred in acclimatizing imported animals.

In regard to many of the diseases, animals bred in the country, or in the parts of the country where they exist, either become tolerant of them or immunized against them (or, in the words of the country, 'salted'), through having mild attacks of them when quite young; but imported animals often suffer severely.

The High Veld is fairly healthy for all kinds of stock, and animals can be acclimatised there with greater safety than in any other part of the country; but the introduction of animals from oversea into the warmer localities and the Bush country is a hazardous business, and so—though to a lesser extent—is the movement of stock from the High Veld into these areas. The existence in certain localities of plants poisonous to live stock has already been mentioned.

The different diseases, and other obstacles to the importation of live stock, are now being thoroughly investigated by the various Departments of Agriculture (see section at end of article). Light has already been shed on some of them, and it is hoped will soon be forthcoming on others. Private individuals are also striving to improve the breeds of live stock by devoting more attention to them, and by the introduction of pure-bred sires. As a matter of fact, there have been occasional introductions of pure-bred stock since the days of the first occupation of the country by Europeans, and the influence of animals so imported is visible to-day; though the work was performed in such a spasmodic, unsystematic, unscientific manner that the results were not as great as they might have been, nor commensurate with the expenditure.

The prevalence of insect pests is a serious nuisance to stock farmers. Not only do they act as carriers of disease, and as the actual cause of the disease in the case of internal parasites, but the ticks more especially, which abound in the Bush Veld, cause great loss simply by sucking the blood of animals. All animals, even poultry, are liable to be infected with them. The remedy is constantly spraying or dipping the animals with an insecticide, or starving the ticks out by completely clearing the veld of stock for a year or more.

Horses.—The 'Boer horse' and the 'Basuto pony' are the native types of the country. Both are comparatively small, 13·2 to about 14 hands, stout in build and rounded in frame. The predominant colours are browns and bays. They are very hardy, possess much 'staying power', are capable of performing much saddle and 'light cart' work on coarse fodder, and in comparison to their size carry 'heavy weights'. The type of horse in greatest demand is a hardy comfortable hack, and at the same time a horse capable of doing 'Cape cart' or light 'trap' work at a steady pace over a long distance. For this purpose the Arab and the Thoroughbred have to the greatest extent been used for improving the size, fleetness, and quality of the offspring from country-bred mares, and for supplying the demand for a better-bred horse for remounts.

The Governments of the Transvaal and the Orange River Colony maintain stud farms, from which are leased to horse-breeders a goodly number of Thoroughbred stallions, with obviously beneficial results. Two endemic diseases, 'horse sickness' and 'biliary fever', which occur over a great part of South Africa, particularly in the northern territories, prevent horse-breeding from being carried out on a more extensive scale. Much of this land is suitable for raising horses cheaply, and with suitable shelter and winter feeding good serviceable horses for military and private purposes can be bred.

Mules and Donkeys.—Mule-breeding is carried on, but the output is insufficient to supply

the demand, consequently mules are imported—chiefly from the Argentine.

The Cape Colony Government has rendered considerable assistance to mule-breeding by importing Catalonian Jack donkeys. Recently the Transvaal Government has given some attention to the matter by importing donkey sires of the same kind, and also a few Catalonian mares. The donkeys of the country, though small, are in some districts, particularly those in which disease regulations prevent cattle being used for transport, and again in 'horse-sickness' localities, largely used for transport.

Cattle.—Two fairly distinct indigenous types are found, *i.e.* the 'Afrikander' and Native cattle — Matabele, Mashonaland, Angoni, and Zulu. The 'Afrikander' is essentially a 'trek ox'. Active, intelligent, and docile when trained, and built on suitable lines, it is eminently suitable for draught work. Its history is wrapt in mystery, but it is generally believed that the cattle of Portugal had, several generations ago, some influence upon its development. The pure-bred Afrikander is recognized to be red in colour, with a rather long, narrow head; elegant, long, and sweeping horns; heavy muscular neck and shoulders (indicative of draught power); a rounded body with sloping hind quarters, a long thin tail, and fine bones throughout. In its general characteristics and expression this breed is somewhat deerlike. It possesses great natural hardihood, and maintains its condition well under adverse circumstances; but its growth and maturity are very slow, and as slaughter cattle of good quality the breed is too thin of flesh in the best parts, and the fore quarters are too heavy in proportion to the hind quarters. The full-grown ox, at six to eight years, weighs about 650 lb. dressed carcass. As foundation stock, the breed is of the greatest value for grading up with sires of improved breeds.

The native cattle mentioned derive their names from the territories in which they are to be found, mostly in the possession of the native races. They are less definite in type than the Afrikander, and are of mixed colours, small, much rounded in outline, and of good quality. Their dressed carcass weight at full growth is from 350 to 450 lb.; the Angoni and Mashonaland cattle being the smallest.

Among imported breeds, the black-and-white Dutch cattle, *i.e.* the 'Friesch' (Friesian) breed from Holland, have to the greatest extent been used for improving the stock of the country. This cross produces an animal large in size, coarse in frame, thin of flesh, but of improved milking qualities. A large number of grade cattle, chiefly black and black-and-white, of this description are to be found in the country, and make useful general-purpose cattle.

British breeds of live stock are gaining in popularity, and are being introduced to an increasing extent. The Shorthorn, but more largely the 'South Devon' breed, are the breeds at present most in favour on large stock farms. In the Cape Peninsula a number of Ayrshire and Jersey herds are kept. These two breeds have, together with the 'Friesch' and the 'Kerry', played an important part in the creation of the famous 'Cape Dairy Cow'. The Hereford, Aberdeen-Angus, and Sussex breeds have of recent years given most promising results.

It is yet too early to decide what improved breeds are the most suited to the country, but briefly stated, the position at present is as follows. The 'Friesch', South Devons, and Shorthorns (including Red Lincoln) appear to be adapted only to the best grazing land and to farms where winter fodder, either in the shape of green pasture or artificial feeding, can be supplied. Among beef breeds, Hereford, Aberdeen-Angus, and Sussex prove hardier and more thrifty under less favourable conditions. Of the dairy breeds, the Ayrshire appears to be more hardy than either the Jersey or 'Friesch' under similar conditions. Red Polls and North Devons have been tried with varied success, but do not appear to be increasing in favour.

The conditions of the country at the present time are more adapted to the maintenance of beef than of dairy breeds, on account of their greater hardihood and better constitution. Nevertheless dairying is making headway, and with more knowledge and enterprise in connection with the provision of winter feeding and shelter, the industry will advance.

The breeding of cattle for draught purposes, or 'trek cattle' as they are termed, is now generally regarded as being of secondary importance to cattle for slaughter and dairying purposes. The appreciation of the fact that improvement in the class of stock reared must go hand in hand with better methods of management in order to obtain the best results, is being recognized more and more by the South African stock-breeders.

Realizing the importance of establishing pure-bred herds in the country, and the difficulty for private enterprise to carry it out, the Transvaal Government, and to a lesser extent the Government of the Orange River Colony, have established pedigree herds of different breeds upon their stud and experimental farms. Pure-bred bulls from this stock are sold to stock-breeders throughout the country.

Sheep.—The sheep native to the country are commonly called 'Afrikander' or 'Fat-tailed'. The head is brown or black, often with white marks, and the body is white covered only with hair. It stands on rather long legs, and is long and narrow, the shoulders and quarters are small, and the tail is, when in good condition, very large and fatty, often weighing 7 lb. The average weight of the carcass is about 45 lb. It is considered that this fatty tail is a provision of Nature, in order to maintain the vitality of the sheep during prolonged periods of drought. These sheep are undoubtedly very hardy, and thrive in districts to which woolled sheep are not suited. One lamb only is born at each parturition, and these sheep will 'take the ram' when still suckling their lambs. In this way, two crops of lambs are often reared during the year. Indeed, if this breed is allowed to have a long resting period, the tails become so large with the improvement in condition that it is a physical impossibility for sexual intercourse to take place.

The small, short-tailed and thick-set black-headed 'Persian' sheep, native to the southern parts of Egypt and Somaliland, is very largely used for crossing with the Afrikander. The 'Persians' are equally hardy and more compact sheep, possessing mutton of fine flavour and fine in fibre. Furthermore, the lambs of the Persian cross mature early. When the time arrives for an export trade to be undertaken—and it does not appear to be far distant—there is some prospect that the carcasses of these sheep will find a satisfactory European market. The joints and cuts are small, but the quality is good, and there is reason to suppose they would be popular with the small householder. The sheep industry of South Africa, however, depends upon its export of wool. Large areas of country, still insufficiently stocked, are almost ideal for growing Merino sheep and wool of the highest quality. History relates that Merino sheep were exported to Australia from the Cape Colony for the purpose of improving the sheep of that continent. To-day the position is reversed. South Africa is buying Merino sheep from Australia for the same purpose. Rapid strides are being made in improving the quality of the wool produced, and improved methods of classification, packing, and so forth, are enhancing the value of South African wool in the European markets. The Cape Colony is the chief exporter of Merino wool, but the Orange River Colony and Transvaal are making rapid progress in this direction. Parts of the country where sheep cannot at the present time be successfully reared will, when it has become grazed down by large stock, become suited for this purpose, and the area of sheep land will be extended.

A few British breeds of sheep, in small numbers, have been introduced for crossing purposes, but the matter is still more or less in an experimental stage. On the whole, the short-woolled Down breeds appear to be likely to prove the most suitable. Crossed on the Afrikander or Afrikander-Persian, a good and heavy mutton sheep is produced, which at the same time grows a fleece of coarse wool.

Goats.—A type of goat common to the country is the 'Boer' goat, whose chief value lies in its hardihood, and power to thrive in districts unsuitable for sheep. In such places its flesh is used for meat, and the hides exported.

Large flocks of Angora goats are kept in the Cape Colony, from which is exported some of the finest mohair the world produces. Great attention has been paid to their breeding and improvement, and the export of these goats from the country is jealously guarded by regulations. The large area of Karoo land in the Cape Colony, where small and nutritious 'bush' of many kinds grow, is ideal for raising goats.

Ostriches.—The Cape Colony is even more famous for its ostrich feathers, in which it has practically a monopoly of the world's trade. Here the African ostrich has been domesticated, and several hundreds of birds are often kept on each farm. See article OSTRICH FARMING.

Pigs.—In the northern and less inhabited areas the wart-hog or wild pig is still found in a wild state. Then a type of pig, black in colour, with narrow, straight head, short thick body, very fat and coarse, is practically native to the country. At full growth the carcass weight of this pig is about 120 lb.

On the whole, pig-keeping does not receive the attention it deserves; the pigs are generally allowed to roam about the farm and shift for themselves. Several breeders are, however, now giving increased attention to the management of pigs, and a great improvement in the class of pig bred in the country is taking place. This is particularly noticeable in the vicinity of mining areas, where large quantities of waste food from the 'native compounds' are obtained cheaply. A few bacon factories have been established in different parts of the country; and with the extension of the dairy industry, the pork and bacon production in the country is certain to increase.

The Berkshire, Large Black, Tamworth, and Yorkshire (especially the Large White) are all bred in the country, and crossed with the common native and cross-bred pigs. Of these breeds, the Berkshire and Large Black are likely to prove the most suitable for the conditions of the country. The Large White Yorkshire suffers from 'sunburn', and the Tamworth is often unthrifty, particularly in cold districts, and takes longer to come to maturity.

POULTRY.—All the ordinary breeds of poultry are kept, but, as a rule, the lighter breeds thrive better than the heavier and more clumsy ones. Judging from the number of wild game birds, poultry should do particularly well in South Africa, but, like live stock, they are afflicted with a good many mysterious ailments. The investigation of these diseases, and the discovery of remedies or preventives for them, will confer a great boon on poultry keepers and on the country at large.

DISEASES OF DOMESTICATED STOCK IN SOUTH AFRICA.—For many years South Africa had more than its share of stock diseases, since many of the European plagues obtained a hold in South Africa, in addition to those which belonged to the class of tropical diseases.

Thus at one time pleuropneumonia and rinderpest in cattle, glanders and epizootic lymphangitis in equines were very prevalent, but, thanks to proper legislation and precautions by the various agricultural departments, these diseases have been effectively dealt with. Rinderpest and foot-and-mouth disease have completely disappeared; glanders and epizootic lymphangitis are under proper control, and there is every reason to believe that under the present system, and with the assistance of the Governments, these latter diseases will also disappear.

Of the tropical diseases introduced into South Africa the most formidable one is East Coast fever, which kills about 95 per cent of cattle affected. It is due to the presence of a blood parasite called *Piroplasma parvum*, and is carried by ticks of the Rhipicephalidæ. This disease is still known in a few parts of Rhodesia, some parts of the Transvaal, and is very prevalent in Natal. Successful legislation has been based on (1) a thorough knowledge of the way in which it is spread; (2) the fact that only a

sick animal carries the infection; and (3) that after a certain time an infected area becomes clean if the cattle are removed. In the two former countries it has gradually been driven back, and every reason exists to believe that it will be finally stamped out.

Redwater in cattle is known to have been introduced into South Africa, but it has so established itself throughout the various parts that it has become endemic. The disease is due to the presence of *Piroplasma bigeminum* in the blood. The immune animal retains the infection in the blood, and since the disease is carried by ticks (the blue tick) it is easily understood that wherever immune animals and ticks are present the disease will remain. Fortunately animals born in the country do not suffer so much from it, and, as a rule, recover, so that a herd can be reared immune against this disease. It follows therefore that imported animals from countries where no redwater exists are the principal sufferers. Prevention of the disease in imported animals lies in stabling, and only the progeny should be exposed to infection. Preventive inoculation with blood of immune animals is effective for South African cattle born in areas free of redwater, but is dangerous for imported cattle.

Under the name gall-sickness of cattle a number of diseases are included, due to various causes. One is the dry condition of the veld at certain seasons of the year. Another is specific vegetable poisonings; but the majority are specific blood diseases, either due to a *Trypanosome*, to a *Spirillum*, or to a *Piroplasm*; and in a great many cases the sequel of ordinary redwater ranges under this name. Gall-sickness has been spoken of by farmers as the most prevalent disease, yet scientifically in every instance a special diagnosis will have to be made, as the term includes so many affections.

The most formidable sheep disease is blue tongue. It comes as an epidemic in certain seasons of the year, principally after the rainy season, and it may then be seen throughout the country, although the higher and drier a locality the less it is noted. It is due to an ultra-visible micro-organism which is present in the blood. The disease seems to be insect-carried, since insect-proof seclusion means prevention. A successful preventive consists of a protective vaccination which renders the animal immune.

In cattle, sheep, and goats of the Bushveld a disease occurs known as heartwater, also due to an ultra-visible micro-organism, and carried by a species of tick known as 'bont' or Tortoise-shell ticks. It is frequently included under the term 'Bush-sickness' of cattle. Its prevention lies in the clearing of an infected farm until the ticks have been starved out.

The specific diseases of horses and mules of this country are (1) the devastating horse-sickness, and (2) biliary fever. The former ravages with varying virulency in the different years. The bad years are known to be those of heavy and continuous rains, when the mortality reaches a very high percentage. It is caused by an ultra-visible micro-organism, and is probably carried by mosquitoes; anyway, the mosquito theory explains all the facts noted by farmers, in the best way. There are two forms distinguished: the dun-horse-sickness and the dik-kop. They are two expressions indicating a certain symptom which is present in the one and not present in the other, namely, the swollen head (dik-kop). The main lesions of dun-kop are found in the lungs. Animals which recover from the disease are called 'salted', and are considered to be immune; but the immunity is not complete, although salted animals do not succumb to the same extent as non-salted animals. Prevention lies in mosquito-proof seclusion during the mosquito season. Mules can be rendered immune by an inoculation, and are then protected to the extent of about 98 per cent.

Biliary fever is due to a Piroplasm (*Piroplasma equi*), and attacks all equines. As in redwater, young animals do not suffer from it so much, and easily recover. These, together with imported animals which have recovered from the disease, retain the infection in the blood, and as the disease is carried by ticks, the veld is permanently infected. Country-bred animals do not suffer much from it, and it is the imported animal which is the most susceptible. The prevention is based on the same principles as in redwater.

The so-called tsetse-fly diseases (Trypanosomiasis) have, with the exception of a small area in Zululand and in some parts of Rhodesia, completely disappeared.

In addition to these tropical diseases, anthrax is known in South Africa amongst all stock, but is limited to certain parts. Quarter-evil in cattle is unequally distributed throughout South Africa, but can be successfully dealt with by a preventive inoculation. Tuberculosis is not known amongst the Afrikander cattle, but in imported stock and their progeny. Scab is common amongst sheep and goats, and notwithstanding the many efforts of the various Governments, has not yet been successfully dealt with. Energetic farmers can easily manage to keep their stock free from it.

One of the greatest troubles of sheep-breeding is the presence of intestinal parasites, principally round worm, the wireworms (Strongylus), and also tapeworms. There are successful treatments, and many of these troubles could be overcome once sheep-rearing and pasturing is adapted to the life-history of these parasites.

There are some diseases the causes of which are not quite clear, viz. osteoporosis in horses, the so-called 'lam-ziekte' and 'stijfziekte' in cattle, and the 'gauwziekte' in sheep. Others are due to specific vegetable poisonings of which we have not yet sufficient knowledge. Amongst swine, only swine fever has hitherto been seen in some outbreaks; measles (Cysticercus), however, is very prevalent, principally owing to the insanitary habits of the natives. [F. B. S.]

South Devon Cattle. See Devon Cattle.

South Devon Sheep.—This is a long-woolled breed which has become established in South Devon and in part of Cornwall.

Probably if records were available one would find that it traces its origin to much the same

source as Devon Long-wool. The introduction into the south of England of the Leicester had no doubt a great deal to do with the evolution of both this and the Devon Long-woolled breed. But the South Devon sheep has been bred in its purity so long, that it has, without question, become a breed of undoubted purity and prepotency—a breed that is able to transmit to its progeny its merits and characteristics. We have no better or higher authority to refer to for a detailed account of its merits than the preface published in the first volume of the South Devon Flock Book. It is therein stated that the South Devon sheep is one with great robustness of constitution, a large, symmetrical, and well-grown sheep, with plenty of bone and muscle, a vigorous and thrifty sheep equally adapted either to the fold or to grazing land, a rapid feeder, coming early to maturity, and a breed that readily responds to liberal treatment, being able also to thrive and do well upon hard fare and exposure. The fleece is of the best quality, for it has a long staple of very lustrous wool, curly and dense on the pelt.

The flesh, unlike many of the whitefaced long-woolled varieties of sheep, is full of lean meat, whilst the carcass of a typical specimen has all the more valuable parts fully developed. As the saying is, the sheep 'cut well'.

It is noted that in the year 1902 the average daily gain of a pen of wether lambs exhibited at Smithfield, and first in their class, worked out at 11·46 oz., or almost $\frac{3}{4}$ lb. *per diem.* Few breeds can give such a large daily gain. At the same show a pen of wethers gave an average daily gain of $7\frac{1}{2}$ oz.; another clear indication of the aptitude of this breed for rapid development.

Flocks of South Devons have been in existence for practically a hundred years; but the breed is not so generally known as others, because the country in which it is pre-eminent is far removed from most of the centres of live-stock activity, and, owing to this, a large proportion of its breeders have hitherto failed to realize the need of making it known farther afield. Indeed it was not until the year 1903 that any definite steps were taken to bring the breed out of its seclusion, and to make an effort to secure for it a position amongst the leading breeds of this country. Much yet remains to be done; but the energetic work of Mr. E. H. Hoskin, of Liskeard, Cornwall, to whom the successful formation of the Breed Association is due, has been continued. At the commencement of the year 1903 it was decided to establish a Flock Book Society, and no efforts have been spared by the more progressive breeders to boom the breed. Lately the South Devon has been exported to New Zealand, to South Africa, and the Argentine, and in all these countries has proved a valuable addition to their sheep stocks.

One of the great drawbacks to the more rapid development of the breed is that a large proportion of the flockmasters own very small flocks, and consequently are not able to employ those methods of advertising and popularizing the breed which large flock-owners in other breeds have undertaken. It is satisfactory to note, however, that the combination of these small flock-owners, as represented by their Breed Society, still continues firm and strong, and it is upon this sound basis that the whole hope of the future depends.

The breed, we may remark in conclusion, is one that has a very marked uniformity; and if seen in its natural condition, upon the various farms in the district, there are few, if any, of the long-woolled breeds that excel it in this respect. Fortunately, the Association has now adopted a method of colouring that will prevent the excess of colouring to which exception has been taken. The former excess of colouring was certainly much to the detriment of the breed, and the alteration now adopted is one of the best things that could happen for the advancement of the interests of this breed, for it enables the South Devon sheep to be exhibited as near under their natural condition as any other breed. Thus the writer is of the opinion that, under the new system, the marvellous quality and great depth of the flesh, the lustrous character and excellent staple of the wool, will secure for them a far larger share of the export trade, and also home demand, than they enjoy at the present time. [W. W. C.]

Southdown Sheep.—Like most of our British breeds of sheep and cattle, the origin of the Southdown breed of sheep is unknown. As a recognized breed it has been in existence for a long time, and appears to have been always associated with the hill range known as the South Downs.

Perhaps the first reliable description of the Southdown sheep before improvement is the one written by Arthur Young about the end of the 18th century. In this article the Southdown is described as being 'very narrow, light in forequarters, standing 2 in. higher behind than in front; legs and faces varied in colour, and might be light in colour or dark (almost black), sandy or speckled according to the taste of the individual breeder; there seems, however, to have been a general dislike to white faces and legs, as it was thought lightness in colour indicated tenderness of constitution; and some breeders bred to produce faces and legs as dark as possible, but most preferred speckled faces and legs'. The first successful attempt to improve the breed was made by John Ellman, who succeeded his father at the Glynde Farm, near Lewes, in 1780, and some few years later commenced a systematic method of breeding which worked such a marvellous improvement in the breed as to bring it into the first rank—a position which the Southdown still maintains, not only as regards beauty of form and hardiness of constitution, but also with respect to fine quality of wool and mutton.

In carrying out the early improvements Ellman always laid very great stress on keeping up the quality of the fleece to the highest possible state of perfection; arguing that the best-woolled sheep were also the best feeding sheep, yielding the best mutton, and moreover were hardier in constitution and much better able to withstand the bleak downs in winter; and as they dropped lambs much better covered

Photo Chas Reid

SOUTH DEVON RAM

FIRST PRIZE WINNER, R A S E SHOW 1906

Photo Chas Reid

SOUTH DEVON EWES

FIRST PRIZE PEN, R A S E. SHOW, 1900

with wool, there were fewer losses both of lambs and ewes at lambing time.

The principle adopted by Ellman in breeding rams was to select about 60 of his best-woolled and best-made sheep; these were mated with his best ram, and the best rams selected from the progeny. He greatly disapproved of close or in-breeding; and when it became necessary to bring fresh blood into the flock, he selected 50 of the best ewes from a neighbour's flock. These were put to his best ram, and stock rams were selected from the lambs. Ellman was also strongly opposed to crossing the Southdown with any other breed.

In the selection of sheep for mating, Ellman emphasized the importance of each breeder making a complete and careful examination of all the chief points, and warned them against making a selection for one or two points only. He said: 'One man will look for a good head and colour of face, another may observe the neck, and the attention of most is directed to one particular point, and should it please their fancy they conclude the sheep to be good, though in other points it may be strikingly defective'. At the same time Ellman strongly enforced the now well-recognized principle, that by careful selection and judicious mating it is quite possible to breed out inferior points and breed in good points.

Ellman's system very quickly brought about a great improvement in the quality of the Southdown, and created a wider demand for them, as is shown by the record of sales. In 1787 Lord Waldegrave purchased two rams from Glynde flock for 10 gs. apiece, a price which had never hitherto been obtained; the previous year Arthur Young bought 80 ewes for 18*s.* each and sent them into Suffolk. From 1790 onwards Southdowns were rapidly introduced into Norfolk. In 1793 that noted agriculturist Coke of Holkham bought 80 ewes, for which he paid 35*s.* each. In 1796 the first 50-guinea ram was sold by Ellman to a Mr. Goodenough, of Dorset; and from this time for many years onwards there was a regular demand for all the spare rams from Glynde, some being hired out for the season at prices varying from 20 to 100 gs. In the year 1800 the Duke of Bedford bought 200 ewes for 500 gs., and in 1802 and 1803 hired a ram for the two seasons for 300 gs., this being the highest price Ellman ever received for the letting of a ram. About this time also the Southdowns were introduced into Ireland by Lord Sligo.

The following is a list of the more important breeders and flocks of Southdown sheep:—

The old-established flock owned by the Duke of Bedford, and probably descended from 50 Southdowns bought from Ellman in 1807: from its foundation the flock has been carefully bred to maintain purity and the true Southdown type; the famous Goodwood flock, the property of the Duke of Richmond, and mentioned by Arthur Young in his Annals of Agriculture (1793), which has produced many noted prizewinners; the Kingston flock, founded in 1787 by W. Gorringe, and presently owned by Col. and Mr. L. Gorringe; the Duke flock, instituted about the beginning of last century by Thomas Duke, and now owned by his grandson, C. G. S. Chapman Duke: this flock is notable for the good form and hardy constitution of the sheep, and for the high quality of its wool; the celebrated Thorney flock, descended from the famous Hart strain of Southdowns, founded in 1820, and now owned by Mr. H. Padwick; the Babraham flock, presently owned by Mr. C. R. W. Adeane, founded early last century by Jonas Webb: it has produced many noted prizewinners, and individual rams have commanded high prices both at home and abroad. Among other noted flocks are the splendid flock of A. Heasman, and the flocks of His Majesty the King, the flocks of F. N. Hobgen, E. Hobgen, Sir Jeremiah Colman, Admiral Hon. T. S. Brand, G. Hampton, Pagham Harbour Company, Duke of Hamilton, Jockey Club, A. Cooper, W. M. Cazelet, J. Ellis, Sir T. Gooch, Executors of Col. M'Calmont, Sir Julius Wernher, Duke of Northumberland, J. Tompkins, Col. W. W. Hammond, Earl Cadogan, J. & H. Robinson, H. & J. Stacey, Sir William Throckmorton, H. Willet.

Management, Points, and Characteristics.—On a typical Southdown farm during autumn and winter, the ewes have a limited supply of roots, but have a plentiful supply of oat straw or hay, with a good grass run on the downs. Some little time before lambing commences, they are brought into the lambing yards and given a liberal allowance of sainfoin or clover hay or well-harvested pea haulm, but usually very little if any concentrated food. Lambing is usually arranged to take place in February or the beginning of March, and the ewes are expected to average 1 to 1½ lambs per head.

When lambs are four or five days old they are turned out with the ewes into a dry early pasture; the ewes are now allowed a liberal diet consisting of roots (usually mangels), sainfoin or clover hay, and concentrated food. Gradually they are drafted off on to a fold of Thousand-headed Kale, which keeps the flock until spring catch crops are ready. These consist of, first, winter rye, barley, and oats, and, later, trifolium and winter vetches, with spring vetches to follow. The above crops are sown in succession so as to obtain a regular supply of succulent food throughout the early spring and summer down to about the end of July.

About this time (or a little before) the lambs are separated from the ewes and turned on to young aftermath of seeds or sainfoin, the ewes being transferred to a bare pasture on some distant part of the farm, and kept on low diet until their milk is dried up and lambs are thoroughly weaned.

Towards the end of July or at the beginning of August, rape or mustard sown after feeding-off spring catch crops will be ready to fold; and these crops, together with aftermath seeds and sainfoin, drumhead cabbages and early turnips, will provide a plentiful supply of nourishing and healthy food through late summer and early autumn, thus bringing the ewes into a strong, healthy, and fit condition for taking the ram in September or early October. Previous to bringing in the ram, the broken-mouthed

and aged ewes and those having bad udders are drafted off for sale or to fatten off before winter. The wether and inferior ewe lambs are also drawn, and sold away or kept to fatten off during following spring and summer; the ewe lambs which will eventually be brought into the flock are kept in a good thriving condition but not allowed to get too fat, so that they may be in a strong, healthy condition to take the ram in the next autumn.

Points.—The colour of the face and legs should be a uniform mousy-brown, not too dark or too light, and not speckled; a light shade of brown is usually preferred to a dark shade. Some breeders think a light colour indicates tender constitution; others say: 'this is not so, though a very light shade is not desirable'. The top of the head should be well covered with short wool, which should extend round the ears and also a little on the back of the ears, and there should be complete absence of horn scurs; the jaw should be neat and light, and well covered with wool, which is an indication that the sheep will be well woolled on the belly; the head well set on, and neck not too short, but strong and muscular, and spreading out well to meet the shoulders, which should be wide, and chest broad and deep; the line of back from the setting on of the head to hind-quarters should be perfectly level, with a strong loin and good dock; the thighs should be well let down and well covered with flesh, the twist being well rounded and filled in with meat reaching down to the hock, thus producing a short, thick, round leg of mutton—a noted feature of the Southdown sheep. A delicate pink skin is absolutely essential; a skin having a dark or bluish tinge is highly objectionable; a good skin indicates quality both as regards tendency to fatten, quality of wool, and good breeding. The character of the fleece is of the highest importance. There should be no black fibres present, and the fibres forming the fleece should be uniform in length at the ends, and densely but evenly packed together so as to form a thick, close covering almost impenetrable to driving rain, snow, or even the maggot fly. It is largely owing to the close character of the fleece that the Southdown sheep is able to withstand the strong gales and storms of rain and snow which sweep over the bleak downs from the Channel. The somewhat low price of wool during past years has caused some flockmasters to pay more attention to size of carcass than quality of wool, with the result that in some flocks the fleece has deteriorated; it has become more open in character, and the wool fibres being less densely packed, it forms an inferior protection. In summer the sheep are more liable to be struck by maggot flies, and in winter are much less able to withstand the cold on the bleak downs, and so are much more subject to chills; the result being a much greater mortality in both ewes and lambs. The best flockmasters, and especially those who occupy high-lying downs, are very careful to maintain the high quality of the fleece, and rigidly weed out those animals which do not in this respect come up to a high standard.

It is on such farms that the true type and hardy characteristics of the Southdown are best seen; and for this reason the best rams from these hill flocks are in demand by breeders in various parts of this country and abroad who are anxious to retain the true Southdown character in their flocks.

As regards size, the Southdown is classed as a small sheep, the average weight being usually taken at from 8 to 10 st., but these weights are frequently greatly exceeded. At the Smithfield Club fat-stock show in 1906 the pen of three wethers which won the breed cup for King Edward averaged over 15 st. per head at 21 months old, and the following year the breed cup was won by Mr. Adeane with a pen of three lambs which at 10 months old weighed on an average over 10 st. per head. These records show that with well-bred stock and proper management good weights may be obtained at a comparatively early age.

Considered as a sheep for the tenant farmer the Southdown has many points of recommendation. Southdowns are particularly well adapted for close folding; being quiet and docile they are easily kept in bounds, a high or strong fence not being essential. Though so well suited for the fold, they are also very active sheep, and, if occasion requires, are able to travel long distances and adapt themselves to open grazing on the downs, or in enclosed pastures in the lower parts of the country. Moreover, they are very hardy, produce excellent wool, and keep in good condition on a moderate diet; and when close folded and fed liberally they give a good return for extra food, as they fatten rapidly and produce mutton of first-rate quality.

As an example of what ordinary Southdowns will do when thickly stocked on a poor pasture, we may quote from an experiment conducted by the writer under the auspices of the East Sussex County Council in the summer of 1906. For the purpose of this experiment 15 tegs were grazed on 1⅝ ac. of poor pasture. During a period of five weeks the sheep had an average of ·54 lb. per head per day of equal parts of decorticated and undecorticated cotton cake; the average live-weight increase per head per day during the period was ·56 lb.; this increase, for sheep which weighed about 8 st. per head and fed under the above conditions, may be regarded as highly satisfactory.

As a butcher's sheep the quality of the Southdown mutton is well known; the flesh contains a greater proportion of lean to fat than the larger breeds, and not only is the proportion of fat smaller, the flavour is of such a high order that many persons unable to eat fat mutton from other breeds can relish that from a Southdown; the lean flesh also is a much darker red than other breeds, and the joints, being small and compact, are in great favour with most butchers and housekeepers. It is on account of the high quality of mutton that the breed is so largely kept and so well liked in France; and it is the Southdown, or the Southdown crossed with the native French breeds, from which are produced the best mutton sheep, known to the

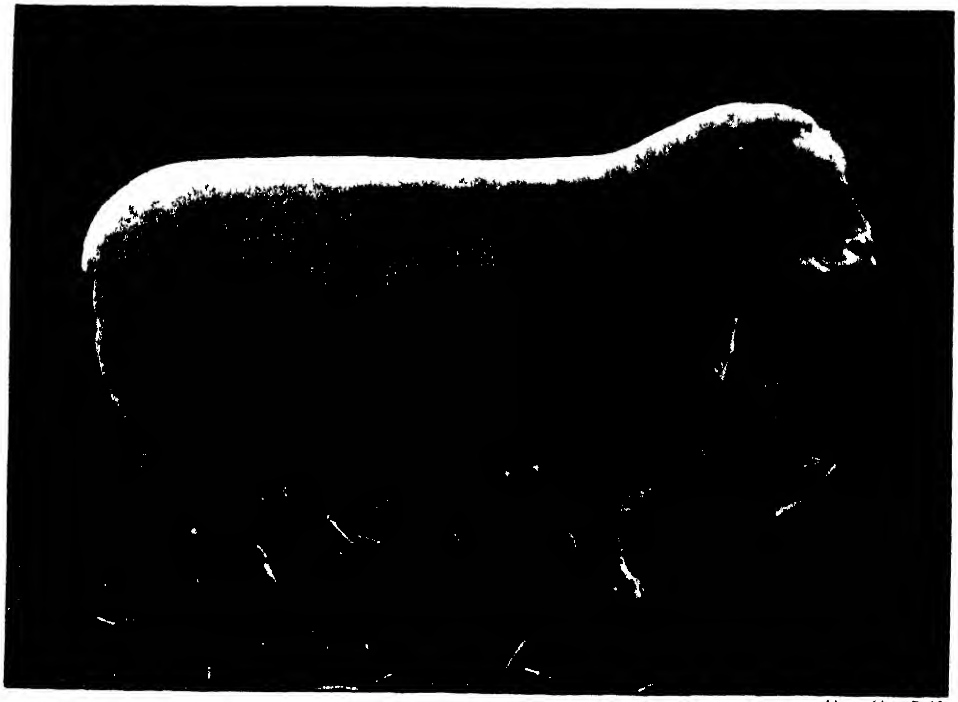


Photo Chas. Reid

SOUTHDOWN TWO-SHEAR RAM

FIRST AT R.A.S.E. SHOW, 1910

Photo Chas. Reid.

SOUTHDOWN EWE

BEST OF CHAMPIONSHIP PEN, R.A.S.E. ...

Parisian butchers as *prés salés*. M. L. Pautet, a French writer on Southdown sheep, says: 'The sheep known as *prés salés* are those born and kept near the sea-coast mostly on the coast of Normandy and Brittany. They are not any one particular breed, but usually crosses of various breeds. The effects of the sea air and salt on the food and the constitution of the sheep in general is to produce mutton of the finest quality, both in colour and flavour, which is greatly appreciated by the French gourmets; and as the legs of mutton are best liked when short, thick, and well-rounded, the Southdown is the breed which, above all others, produces joints and quality of mutton most in demand, and for which the highest prices are paid.' M. Pautet goes on to say: 'For the following reasons is the Southdown most sought after: it matures early; conformation is perfect; bone is fine; fleece excellent; flesh exquisite; it is in itself a *prés salé*, it carries the name of its habitat, as the word Southdown signifies dunes of the south, *i.e.* hills bordering on the sea-coast known by the English as the Channel'.

French breeds used for crossing with Southdowns include the Tronnier, the Cauchoise, Caennaise, Cotentine, and Cretonne.

In Australia and the United States the value of the Southdown ram for crossing with Merino ewes to produce butcher's animals has been made the subject of comparative tests. In Australia, where a test was made with most of the leading British breeds of sheep, the Southdown cross came out first class. It has been noted in these tests that the lambs from this cross come away strong and robust, with plenty of vitality; hence they develop rapidly and are ready for the butcher early, thus giving a good return for food consumed.

That the Southdowns have a remarkable power of adapting themselves to varied climates and situations may be inferred from the fact that they have been exported to many parts of the civilized world. Amongst the principal countries may be named France, Spain, Portugal, Switzerland, Germany, Russia, Sweden, Norway, Finland, Australia, Tasmania, New Zealand, Canada, United States, Mexico, South America, West Indies, Japan.

In our own country the good influence that the Southdown has had on our short-woolled breeds can hardly be overestimated; and practically all the short-wools have been improved at one time or another by the introduction of Southdown blood. For crossing to produce mutton, rams are largely used on Kent ewes, and another cross which is held in high favour by men who fatten for the butcher is Southdown and Suffolk; here again the cross-bred is larger than the Southdown, and the quality of the mutton is excellent.

The numerous successes gained by the Southdown at the principal fat-stock shows stamp it as being a favourite mutton sheep. At the Smithfield Show, from 1832 to 1873, a period of 42 years, the prize for the best pen of short-woolled sheep went to Southdowns every year excepting 1872. During a period of 21 years (1869 to 1889), when a champion prize was given for the best pen of sheep in the show, it was won eleven times by the Southdown; none of the other breeds succeeded in winning more than three times. From 1890 to 1908 inclusive, the prize for the best pen of short-woolled sheep has been won on nine occasions by Southdowns.

Markets and Prices.—With reference to the prices realized for Southdowns at important sales during 1908, we may quote from the returns made at the dispersal of the Compton flock, owned by the late Duke of Devonshire, and the prices realized at the Chichester show and sale. At the sale of the Compton flock the highest price obtained for a two-shear ram was 80 gs., the average for 5 being £31, 5*s*. For yearling rams, highest price 35 gs., and average for 24, £16, 7*s*. Average price for 6 ram lambs, £18, 11*s*., and highest price 44 gs. Yearling ewes, highest price 19 gs., average £8, 19*s*. Two-year-old ewes, highest price 16½ gs., average £6, 7*s*. Full-mouth ewes, highest price 10 gs., average £5, 7*s*. Ewe lambs sold as high as 81*s*., and averaged 57*s*. These prices may be taken to represent the value of pure-bred Southdowns from a flock which has been brought to a high state of excellence.

The following particulars give the highest and average prices obtained by the various classes of sheep in 1908 at the Chichester annual show and sale, which is probably the most important public sale of Southdown sheep held in Great Britain. In the class of yearling rams the total number sold was 265, and the average price obtained was £7, 16*s*. 9*d*.; the average of the six best lots (54 in all) was £13, 5*s*. 6*d*., and the record price was 50 gs. Of ram lambs there were sold 209 at an average price of £4, 12*s*. 11*d*.; the average of the six best lots (57 in all) was £6, 16*s*. 8*d*., and the highest price for a single ram lamb was 21 gs. In the class of yearling ewes the total number sold was 1522, and the average price was 52*s*. 11*d*. For the six best lots (338 in all) the average was 62*s*. 2*d*., and the highest individual price was 71*s*. 8*d*. In four-tooth and six-tooth classes, average price realized for 146, 43*s*. 6*d*. Draft ewes: average price for 3000, 43*s*. 8*d*.

It is only within recent years that auction sales for Southdowns have been introduced into Sussex, and even now the bulk of the sheep are offered at about twenty fairs held in various parts of the county, some of the most important being Lewes, Lindfield, Heathfield, Findon, Chiddingly, Burgess Hill, Battle, Hailsham, East Grinstead, Eastbourne. The method of disposing by auction is rapidly gaining ground, and in connection with some of the leading fairs auction sales are now held. [W. SOU.]

Southernwood, a fragrant shrub often grown in gardens. See Artemisia.

South Hams, a local appellation for the South Devon cattle (see art. Devon Cattle).

Sowens, or **Sowans,** called in England *flummery*, are a dish prepared by fermenting the husks and siftings of oatmeal in water. The preparation of sowens still lingers in remote country districts near local mills. The husks and siftings of oatmeal, called sowen

'seeds', are steeped in tepid water in a tub, called variously the sowen tub, sowen kit, sowen boat, &c., and the mixture, with or without the addition of some oatmeal, is allowed to ferment for two or three days at a moderate temperature. When the whole is quite acid the liquor is decanted, fresh water added and stirred up, then allowed to settle overnight and decanted again, and so on till the washings are no longer acid. The solid residue is now transferred to the sowen-bowie or sieve, to drain off the remaining liquid, and the mass is cooked like thin porridge with water and served with sweet milk. The dish is very apt to burn, and needs continuous stirring: hence the numerous allusions to 'singit' (singed) sowens. The dish when prepared is not unlike a preparation of oat flour, but with a pleasant acid taste, very refreshing in hot weather. The fermentation process above described is sometimes applied to the siftings of barley and wheat instead of oats; it practically involves the conversion of some of the starch into lactic acid, an anticipation of the natural process of digestion, so that sowens are more readily digested than oatmeal porridge. [J. K.]

Sowers. See BROADCAST SOWERS; DRILLS.

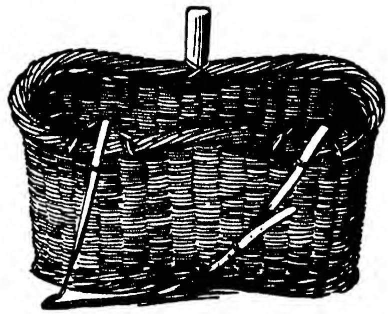
Sowing.—The bulk of farm and garden seeds are sown by one or other of the three following methods: (*a*) by hand distribution, broadcast or in rows; (*b*) by machine where the seed is sown broadcast; (*c*) by machine where the seed is deposited in rows. In Scotland probably three-fourths of the total area under grain is still sown by hand, owing principally to the dampness of the climate and the firmness of the soil. Hand sowing permits of the sowing being done at the quickest rate, with the least expenditure of power. Where the land is firm, or if from lea, most ploughs leave a good seedbed, and if the grain is sown broadcast by hand, there is rarely any difficulty in covering it, nor is much lost. A good sower with one carrier can easily do from 1 to 1½ ac. per hour when sowing with one hand, and when using both hands, and supplied by two carriers, he can get over double that area. In uncertain weather that is a great advantage, as the harrows often work quite cleanly when the drill would clog, hence the reason there is still so much hand sowing of grain.

Broadcast sowing machines for grain have never been in great favour, as the speed is no greater than by hand; and although the uniformity of sowing is somewhat superior, the use of an extra horse and the outlay on the machine has generally been considered to outweigh any advantage gained. With grass and clover seeds it is, however, different, as it is somewhat difficult and rather slow to sow these by hand, whereas with the ordinary machines the distribution of the seed is both speedy and uniform. For this purpose the broadcast distributor has become very popular, and is to be found on almost every farm.

The greatly extended use, during the latter part of last century, of ploughs of the so-called American or concave pattern of mouldboard, which break up and pulverize the furrow, caused an increased demand for grain drills of the lighter pattern. These made considerable headway in many districts, as they saved at least a bushel of seed per acre compared with hand sowing. With the lighter drills, on firm yet free-working land in spring, a pair of horses can do about 1 ac. per hour, with only one man to drive, and a boy or a woman to carry seed and keep the coulters clear. In autumn, in sowing wheat, when the land is often damp and the draught heavier, about ¾ ac. is as much as a pair of horses can drill in an hour.

Other seeds, such as mangold, turnip, carrot, &c., which are usually sown or raised drills, are almost invariably sown by a special machine adapted for the work. Market-garden seeds such as onions, parsley, carrots, &c. are usually sown either by a hand machine specially adapted to the work, or by hand. See arts. BROADCAST SOWERS, BROADCAST SOWING, DRILL HUSBANDRY, DISTRIBUTOR, and DRILLS. [J. S.]

Sowing Baskets, to hold corn for sowing, take various forms. In some cases a circular basket is preferred; in others a longer



Sowing Basket

and narrow basket or skep, holding about a bushel, and suspended by a strap from the shoulders, is used. Metal seed-lips of a somewhat figure-of-eight shape are used in the place of the basket. A wooden stud placed on the side farthest from the man's body, is used to steady the basket when he is sowing. [W. J. M.]

Sowing Fiddle, a portable mechanical broadcaster for sowing seeds, taking its descriptive name from the fiddle-like action which the operator uses to effect distribution. It is decidedly useful, as it does good work, and a novice can use it effectively. A light, canvas-covered box frame is suspended by a strap from the right shoulder, and is carried under the left arm. At the base of the box is a neck with a controlling slide through which the corn passes, its flow being made continuous by a jigger action from an eccentric from a spindle, which carries at its bottom a distributing disk. The disk, which has four radiating ribs, is actuated by means of a thong which forms the string of the bow, and which is passed once round the spindle, like the cord of a jeweller's drill. When reciprocated, as in fiddling, the bow causes the disk to revolve rapidly in alternate directions, giving a throw to ordinary cereals of 30 ft.

Sowing Fiddle

However, in practice, a width of about 15 ft. is found most serviceable. [W. J. M.]

Sowing Machines. See arts. BROADCAST SOWERS; BROADCAST SOWING; DISTRIBUTOR; DRILLS.

Sow-thistle, or **Milk-thistle** (Sonchus), is the name for a genus of succulent herbaceous Composite plants with hollow stems, spiny leaves, milky juice, and yellow flower-heads with the flowers all ligulate. The 'seed' (fruit) is flat and crowned with a tuft of white silky hairs (*pappus*). Three species of the genus are common weeds in arable land, namely: (1) Corn Sow-thistle (*Sonchus arvensis*), (2) Common Annual Sow-thistle (*Sonchus oleraceus*), (3) Sharp-fringed Annual Sow-thistle (*Sonchus asper*).

1. CORN SOW-THISTLE is a deep-rooted perennial with an underground creeping and branched stem from which the green air shoots rise to a height of 3 or 4 ft The stem part is hollow, angular, and succulent, simple at the base, but branched towards the apex, each branch ending in a head of bright-yellow flowers, all the heads arranged so as to stand at a common level. The individual flower-head is large, 1½ in. in diameter, and supported on a stalk clothed, like the involucre of the head, with long spreading dark-coloured hairs. The lower leaves are shaped like those of a Dandelion, but the upper are entire and clasp the stem.

This Sow-thistle extends very rapidly by means of its underground stem, and also reproduces very rapidly, a single plant being capable of maturing over 10,000 'seeds', each provided at its apex with a crown of white silky hairs (*pappus*) to utilize the wind as its seed distributor. The plant is in flower in July and August, and in August and September the seed is ready for distribution. This is one of the weeds most efficient in reducing yield of crop, and most difficult to exterminate once it has become established. Small patches of the weed may be dug out and destroyed; special care must be taken to remove the whole underground stem, for a single piece of it suffices to renew the plant. If the weed is widespread, all shoots must be cut off as soon as they appear, and this cutting must be continued and repeated till the underground stem is exhausted and dies of starvation. For this, the hoe must be kept constantly at work in the root crop, a couple of which crops should be taken in succession. Again, if the land is laid under grass for a few years, the Creeping Sow-thistle dies out. Spraying with sulphate of copper, as for Charlock, diminishes somewhat this pestilent weed.

2. COMMON SOW-THISTLE is an annual cornfield and garden weed, destitute of the creeping underground stem which confers perennial character upon the former species. From a taproot, the air shoot rises to the height of 2 or 3 ft. The upper leaves clasp the stem and have pointed ears at their base. The yellow flower-heads are arranged in umbel-like clusters. The head is comparatively small, from ½ to 1 in. in diameter, and the stalk as well as involucre is practically bald, without the long black hairs characteristic of Creeping Sow-thistle.

To exterminate, seeding must be prevented. Flowering goes on from June to August, and from July onwards the 'seeds' are distributed far and wide by the combined action of the hair crown and the wind. The young plants should accordingly be hoed out in the root crop, and any that escape the hoe should be pulled up later—thus seeding is prevented, and extermination follows.

3. SHARP-FRINGED SOW-THISTLE differs but little from the preceding species; many consider it as a variety. The ears of the upper leaves, however, are rounded, not pointed.

All the Sow-thistles are relished by rabbits and hares, by sheep, goats, and pigs, but horses and cattle do not touch them. [A. N. M'A.]

Soya Bean, the seed of *Glycine Soja*, Benth., Leguminosæ. This is a sub-erect or creeping annual plant, a native of China, Cochin-China, Japan, Java, and acclimatized in India. It is extensively cultivated in most tropical countries as a pulse, and also on account of the rich oil obtained from the seeds, and the valuable cake thereby furnished. In China a sauce called *Soy*, and in Japan a kind of cheese (or curd-cake) called *Natto*, have been prepared from these seeds for many centuries. In 1910 a large trade, from Manchuria to London, was organized in the seed, and much hope was expressed, in some quarters, that the establishment of oil mills in this country, where Soy Bean can be worked up, might compensate for the failure to compete with France (Marseilles) in the preparation of oil from ground-nut (*Arachis hypogæa*), a plant which might be described as own cousin to the Soy, the world's supplies of which come from Africa and India. It is, in fact, one of the numerous eccentricities of trade that England should find it more profitable to import the Manchurian bean rather than to extend her demands for the ground-nut of India. In Manchuria it is cultivated on the plains, where a long winter's frost is followed

by a short temperate but rather wet summer. In India it is grown in the upper provinces mainly, the seed being sown in June to August and harvested from November to December. A soil rich in organic matter is preferred, and nitrate of soda is regarded as its best manure. The chemical composition of the bean places it above most other pulses as an albuminous food, and the cake (after expression of the oil) is, as already stated, an extremely rich cattle food. See next art. [G. W.]

Soya Bean Cake.—This is a material which has recently come very largely into use in Great Britain. It is made from the bean of the Soya plant (*Soya hispida*), a leguminous plant which has long been cultivated in China and Japan, and is there used largely as a vegetable and for making the well-known Soya sauce. The bean is now principally exported to the United Kingdom from Manchuria. Its advent has marked an important addition to our list of feeding materials, and one which, by reason of the higher price of linseed cake and the difficulty of getting good decorticated cotton cake, bids fair to increase rapidly. Being highly nitrogenous in character, the cake is well fitted to take the place of decorticated cotton cake. The beans are not very frequently used by themselves as cattle food, and are somewhat richer than ordinary English beans. They are, however, more generally employed after being pressed into cake. Soya Bean cake would seem to be well adapted as food for milch cows in particular. At the same time it requires to be used with care, and should not be given freely at first. As a rule, it is found to be pure and in good condition, but cases are known of the inclusion, with the Soya Bean, of the poisonous Rangoon and Java beans. The manurial value, owing to the richness of the bean in nitrogen, is very high, and is much about the same as that of decorticated cotton cake. A Soya Bean meal is also sold which has had the oil almost entirely removed by chemical means. The following are analyses of the Soya Beans and of Soya Bean cake:—

	Soya Beans.	Soya Bean Cake.
Moisture ...	10·41	11·40
Oil ...	17·47	6·12
[1] Albuminous compounds	40·50	42·78
Starch, digestible fibre, &c.	22·38	28·41
Woody fibre ...	4·21	5·70
Mineral matter (ash) ...	5·03	5·59
	100·00	100·00
[1] Containing nitrogen ...	6·48	6·85

Included in the ash constituents of the Soya Bean cake are 1·3 per cent of phosphoric acid and 2·2 per cent of potash, so that the manurial value is very similar to that of decorticated cotton cake. [J. A. V.]

Spade Husbandry.—It is curious to reflect that the oldest, the simplest, and the cheapest form of cultivating instrument is also the nearest to perfection. The plough is the only implement, except the spade, which systematically inverts the soil; but the advantage of the latter is that it not only inverts, but at the same time pulverizes. A mechanical digger has long been the dream of the inventor, and to some degree it has been realized in certain types of tillage implements. Nothing has, however, yet appeared which can rival the spade in thoroughness, and adaptability for small plots of ground. The gardener seeks for nothing better; and if we are right in surmising that Adam delved, then the spade is the primitive and original cultivating implement. Just as the plough has never been beaten in the field, so the spade is unrivalled in the garden, and many treatises have been written on the advantages of this form of husbandry over every other. Digging yields results superior to any other method of tillage. It involves no poaching or treading of the seedbed, but presents it at once ready for sowing or planting. It may be shallow, as when the pressure of the foot is dispensed with, but it may be easily carried to a depth of 1 ft., and by deep, double, or trench digging, ground may be dug 3 ft. deep. The only objection to spade husbandry in the field is its expense, and this objection is insuperable. It is the province of the horse, or of power in some form, to cultivate large areas; but spade husbandry is the best system in the garden, the small plot, or in circumstances when labour is cheap and work scarce. [J. WR.]

Spain, Agriculture of. See art. EUROPEAN AGRICULTURE.

Spaniel.—Field Spaniels are of many varieties, the larger of which are known as Springers and the smaller ones as Cockers; but beyond a doubt they have all sprung, as the term Spaniel suggests, from a Spanish source. The most conspicuous members of the Springer family are the Clumbers, Sussex, and the Welsh. These Field Spaniels are of many different colours, the most common of which are black, roan, liver-and-white, and black-and-tan. The Cockers are mostly black, but numerous excellent roans are to be found, and the other Field Spaniel colours are also met with amongst them. Clumbers are the heaviest of all the Springers, and no doubt the most seldom seen, as they are in comparatively few hands, though belonging to a most valuable breed for field purposes, their peculiarity being that they hunt mute. The head of the Clumber is long and massive, the occipital protuberance being strongly developed, the nose large and light in colour, and the eyes hazel and deeply sunken, showing the red haw in the corners. The body is very long and powerful, the loins being strong; the legs are short and extremely heavy in bone, whilst the coat is profuse, and the colour white with golden-brown markings, which should not be too dark in shade. The Sussex Spaniel is smaller in size than the Clumber, and its ears are set on higher, whilst the colour is the uniform rich liver unrelieved by any white markings. In days gone by, the most famous strain of these Spaniels was to be found at Rosehill in Sussex, and a few specimens of these are still to be met with, but they are very rare, as the old breed has been much crossed with the Field Spaniel. The latter variety, by far the most popular of all in the present day, is a smaller dog than the Clumber, and not so heavy about the head. The body of

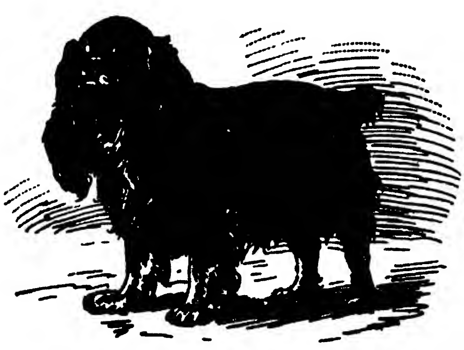
Clumber Spaniel

a Field Spaniel is extremely long, and the legs very short, the coat being long and flat, and thick enough to keep out the cold and wet, though somewhat fine in texture. The Cocker facing is both large and popular, the working abilities of these charming little dogs being deservedly appreciated by sportsmen. As regards their shape and make, the Cockers closely resemble the larger Field Spaniels, though their muzzles by comparison are finer. There is, however, the same expression about the eyes, the low-set ears, lengthy bodies, and short legs; but, as may be expected, the Cocker is not so valuable for retrieving purposes as the larger dogs, simply because he has not the size and strength to bring in a hare. On winged game, however, he is a most excellent little animal. [v. s.]

Toy Spaniel.—In spite of the attention that is being paid to some of the foreign varieties which have been introduced into the country of late years, the King Charles and Blenheim Spaniels have maintained their popularity. In general appearance the two breeds are very much the same, but the Blenheim is a rather lighter-built dog than the King Charles. The main point of distinction between them, however, is one of colour, as the Blenheims are white dogs with rich lemon-red markings of not too dark a shade; a spot of white should always be situated on the centre of the forehead; whilst the King Charles are either black-and-tan, black, white, and tan, or ruby-red. A few years ago the attempt was made to distinguish the tricolour variety as the Prince Charles, but happily the good sense of the public prevented the

Black Cocker Spaniel

alteration from being made permanent. The skulls of Toy Spaniels are large and round, the effect being increased by the long low-set ears, the muzzle being short, though this was not always the case, as in the old days the muzzle was long. The eyes are large and round, the back short, the body deep at the chest, the loins of the Blenheim being a little more inclined to be tucked up than those of the King Charles. The fore legs are of fair length and should be quite straight, the feet being large and well padded, with hair between the toes, whilst the tail is always cut, and should be carried straight out. In the case of both breeds the coat on the body should be long, free from curl and silken in texture, the ears and tail carrying a long fringe of hair, whilst the feathering on the legs should be profuse. If properly reared and not pampered, Toy Spaniels are fairly hardy little



King Charles Spaniel

dogs, and form most excellent companions both indoors and out; but it is to be feared that the constitutions of some strains have been weakened by inbreeding and too much coddling. [V. S.]

Spanish Chestnut. See art. CHESTNUT.

Spanish Fowl has for centuries been known in the United Kingdom and the Netherlands. In appearance it follows the Mediterranean type, that is, light in body, which is small, on legs of medium length, with a flowing tail in the male, and the head surmounted by long wattles and a large single comb, which falls over to one side in the hens. The plumage is dull-black, and rather scanty; the wings are short, thus giving a close appearance to the body. The legs and feet are very dark slate, almost black. The face, instead of being red as in nearly every other breed, is white. At first this was normal, that is, of the usual size, but breeders first developed it coarse and then long. Everything was sacrificed to that one point, perfection of which demanded breeding and keeping under conditions artificial in the extreme. As a consequence, these birds became very delicate, the chickens were difficult to rear; and although the breed has retained a large measure of its fecundity, it is practically useless and unprofitable even as a fancy fowl. [E. B.]

Sparrow. See arts. HEDGE SPARROW; HOUSE SPARROW.

Sparrow-hawk (*Accipiter nisus*).—This, the commonest British bird of prey, is about

Sparrow-hawk

12 in. long (the female rather larger). The long legs, short wings, and cross-barred tail are characteristic. The upper side of the body is bluish-grey (brownish in the female), while the breast, buff in the male and white in the female, is marked with numerous dark transverse streaks. Sparrow-hawks feed on small birds and mammals, being very destructive to young game and poultry. They also destroy large numbers of useful singing birds, and though their prey partly consists of harmful birds and mammals, the mischief done far outweighs the benefits conferred. They therefore form the only exception to the general rule that British birds of prey should be protected from persecution. The large stick-nest, scantily lined with fibre and moss, is usually built high up in the main fork of a tree, or in an inaccessible position among rocks. The three to six grey eggs are blotched with reddish-brown. [J. R. A. D.]

Spartium Junceum (Spanish Broom) is a broomlike plant spread over the Mediterranean region, sometimes cultivated in British gardens. The stems are glossy cylinders, not angular as in British Broom, and the yellow flowers are highly perfumed. The stems yield fibre useful for making thread and cordage. [A. N. M'A.]

Spavin. See arts. BOG SPAVIN; BONE SPAVIN.

Spawn, the underground vegetative part of fungi, being principally of importance to gardeners and arboriculturists in connection with mushrooms and the great variety of fungus pests which are propagated by it. It consists of numerous much-branched threads (*hyphæ*), originating from the minute dustlike spores, and does not correspond to seed as is often supposed. The manufacture of mushroom spawn is an industry of some importance. See art. MUSHROOM. [W. W.]

Spaying, the operation by which female animals are deprived of the sexual desire, is performed chiefly upon pigs with a view to their greater increase in flesh. Sows that have not been operated upon, and are killed during œstrum, prove resistant to salt, and the meat is said to go bad near the bone. The practice favours indiscriminate herding, and is therefore convenient. The operation is deemed unnecessary by many, but a High Court decision (Lewis *v.* Fermor) protects those who do it from the charge of cruelty. Cows are spayed for the purpose of prolonging lactation and favouring the laying on of flesh; but in their case the operation certainly seems cruel, both at the time, and on account of the subsequent suffering, which pigs apparently do not feel. Vicious mares are sometimes spayed with a view to reforming their tempers, and in the majority of cases with success. Bitches and cats undergo the operation for the convenience of their owners, who neither wish to breed or be troubled with frequently recurring periods of œstrum in their pets. The operation is one requiring considerable skill, although commonly practised by an illiterate class of castrators. In the sow, bitch, and cat, the uterus, back to its bifurcation, is removed, together with both ovaries, but in the mare and cow the ovaria only are taken. If bitches are not pregnant at the time of operation a recurrence of œstrum is sometimes noted. [H. L.]

Spearmint (*Mentha viridis*) is the well-known plant which is used for making mint sauce to accompany lamb and green peas. It belongs to the nat. ord. Labiatæ. The plant cultivated in gardens is derived from the wild form which grows in marshes. This, like other Mint species, is a perennial underground creeper. Its leaves are characteristic—bald, bright-green, lanceolate, coarsely toothed, and destitute of a petiole. The odour, due to the presence of an

aromatic essential oil, is very pungent. The taste is more pleasant than that of Peppermint. The lilac flowers are arranged in whorls placed on the leafless terminal part of the stem, at intervals of ½ or ¾ in., the whole forming an interrupted cylindrical spike. The plant is easily propagated by dividing the underground stem in spring, and planting the cuttings where desired. [A. N. M'A.]

Spearwort is the name applied to two poisonous marsh species of Buttercup (Ranunculus) marked by undivided lanceolate leaves, *i.e.* broad near the middle and narrowed at apex and at base. Lesser Spearwort (*Ranunculus flammula*), the common species in wet meadows, is a perennial herb with dwarf stems from 4 to 12 in. high. The flowers appear from June to August; they are yellow like those of the ordinary Buttercup, but smaller, about ½ in. in diameter. This species has proved fatal to horses and cattle that have eaten it.

Greater Spearwort (*Ranunculus Lingua*), a rare species also found in marsh and ditch, is an underground creeping perennial. From the underground stem, bald air shoots rise to the height of from 3 to 5 ft. The flowers are numerous, yellow, and very large; they appear from July to September. [A. N. M'A.]

Species, a group of individuals closely resembling one another in their hereditary characters, and able to breed together. A natural classification, intended to show genuine relationships, is always based on structural and developmental resemblances. Thus whales are not ranked with fishes, nor bats with birds, but both are referred to the Mammalia, with which they agree in all the fundamental features of their structure and development. In the course of this natural classification it is convenient to recognize certain grades or degrees, which are spoken of as species, genera, families, orders, and classes. To give an illustration, all the tigers are said to form the species *Felis tigris*, of the genus Felis, in the family Felidæ, in the order Carnivora, within the class Mammalia. The resemblances of all tigers are very close; very obvious, but not so close, are the resemblances between tigers, lions, jaguars, pumas, cats, &c., which form the genus Felis; wider still are the resemblances between the members of the cat family Felidæ; still wider those between the cats, the dogs, the bears, the seals, and other forms that make up the order Carnivora; and lastly, there are the broad common features that bind Carnivores, Ungulates, Rodents, and other orders together in the class Mammalia.

There is a twofold difficulty in giving an altogether defensible definition of species. In the first place, it is in great part a matter of opinion or of judgment whether a group of similar individuals, fertile *inter se*, and breeding on the whole true, should be called a species or a variety. The question is: Are the peculiarities which the members of the group have in common, and which distinguish them from the members of nearly related groups, important enough to deserve a special name? In the second place, while some species are sharply marked off from their nearest allies—illustrating what is called the discontinuity of species—there are others which are connected by intergrades with allied species. In such cases, a species is a somewhat arbitrarily defined area in a continuous series.

While no rigid definition can be given of a species, seeing that the conception is one of practical convenience and purely relative, there are certain common-sense considerations to be borne in mind.

1. A species is made up of individuals, which usually show minor fluctuations or larger variations when compared with their parents. The specific peculiarities are variable, and when the numbers of individuals showing different degrees of peculiarity are plotted out, they form in most cases what is called the normal curve of frequency. There is usually a proportion between the amount of a variation—estimated by its deviation from the average—and the frequency of its occurrence. Thus in 2600 men taken at random in Britain, there is likely to be a dwarf of 4 ft. 8 in. and a giant of 6 ft. 8 in.; there are likely to be about twelve men of 5 ft. and about twelve men of 6 ft. 4 in.—that is to say, equal numbers on each side of the average of 5 ft. 8 in. Now while species are usually variable in this way, the common characteristics on the strength of which we deem it warrantable to give a specific name to a group of individuals, should exhibit some degree of constancy from one generation to another. In other words, a species implies a certain degree of stability—more than is exhibited by what is called 'an ever-sporting variety'.

2. Sometimes a minute character, such as the shape of a tooth or the marking of a scale, is so constantly characteristic of a group of individuals, that it may be used as a reliable specific character. On the other hand, the peculiarities on the ground of which one species is distinguished from another should always be greater than the peculiarities which crop up among the progeny of a pair. Otherwise, the classifier lands in the absurdity of placing two brothers in different species. As a matter of fact, it has repeatedly happened that one species has been made out of a male and another species out of its mate—the relationship of the two being at first unknown. The caution here indicated requires to be borne in mind in discussions regarding species, but especially when several generations have not been studied.

3. The members of a species are fertile *inter se*, but not usually with members of other species. It is believed by many biologists that a restriction of the range of fertility is a necessary step in the establishment of a new species. Some form of isolation, *e.g.* geographical barriers, may divide a species into two contingents which follow different lines of variation and may become mutually sterile. A well-marked variety is a possible species in the making, and whether it attains specific rank or not, will depend in part on the occurrence of some form of isolation. Species arise from other species by variation, which may be of the nature of small fluctuations or of large mutations. The variants that are

in the direction of increased fitness to the conditions of life survive, while the others are quickly or slowly eliminated. The directive factors—Selection and Isolation—work on the raw material afforded by Variations, and this is the mode of origin of new species. [J. A. T.]

Specific Gravity is the ratio of the mass of a given substance to the mass of an equal volume of a standard substance at a definite temperature, water—that is, pure distilled water—being generally taken as the standard. Gases are, however, generally referred to dry air or to hydrogen as a standard. The specific gravity of some farm products is an important criterion of their value.

In the case of milk, the specific gravity, taken alone, is no guide whatever to quality or to genuineness. Milk contains, in addition to water itself, fats that are lighter and other solids that are heavier than water. Taking the mean specific gravity as 1·030, not only is this diminished by the addition of water, but if the milk is allowed to stand, the upper layers, becoming richer in fat, have a lower specific gravity. On the other hand, the specific gravity is increased by the removal of the cream.

The specific gravity of roots gives a useful indication of their content of dry substance. Suppose a potato to weigh $2\frac{1}{2}$ oz. in air, and to weigh $\frac{1}{4}$ oz. when suspended in water, *i.e.* to lose $2\frac{1}{4}$ oz. when weighed in water, the specific gravity will be the ratio of $2\frac{1}{2}$ to $2\frac{1}{4}$, that is, 1·111. Now if the three figures that follow the decimal point are taken and multiplied by 2, then 43 added, and the result divided by 10, we get an approximate value for the percentage of the dry substance. In the case supposed, $111 \times 2 = 222$; $222 + 43 = 265$; $265 \div 10 = 26{\cdot}5$; that is, the potato contains about $26\frac{1}{2}$ per cent dry matter. Similar formulæ can be worked out for the other roots.

In the case of the cereal grains, the apparent specific gravity in bulk gives a useful indication of quality, though the matter is not so simple as in the case of roots. The weight of grain per bushel is often given as an expression of the character of the grain harvested.

Soil particles vary in their specific gravity according to their nature, as sand, clay, humus, &c. But the real specific gravity of soils, as it is called, that is, the specific gravity of soil particles supposed to be packed together without interspaces, varies within rather narrow limits, say from 2·400 to 2·700 for ordinary soils. The soil as it occurs in the field is packed loosely, and, in the case of the stiffer soils, the looser the packing the better the tilth. The apparent specific gravity, as it is called, that is the weight of, say, a cubic foot of dry soil compared with the weight of a cubic foot of water, gives therefore an indication of the porosity of the soil as it exists in the field. This may vary much more, say from ·850 to 1·500 according as the porosity of the soil varies from 420 to 650 parts per thousand. [C. M. L.]

Speedy Cutting. See art. BRUSHING, INTERFERING, OR CUTTING.

Speir, John, one of the most noted agriculturists of his day, was born in the parish of Dalry, Ayrshire, in 1850, and died in 1910. In 1876 he became tenant of Newton Farm, about seven miles from Glasgow, where he spent the remainder of his life. From 1885 he was a director of the Highland and Agricultural Society; in 1897 he was appointed a member of the Royal Commission on Tuberculosis; in 1898 he was elected President of the Scottish Chamber of Agriculture; and he was a governor of the West of Scotland Agricultural College from its formation in 1899. He travelled very extensively throughout Europe and America, and a few years prior to his death received from King Haakon of Norway the Knighthood of St. Olaf. He was a prolific writer on agricultural subjects, and for many years was a regular contributor to the annual Transactions of the Highland and Agricultural Society. He also contributed largely to the Book of the Farm, and to Green and Young's Cyclopedia of Agriculture; and he wrote about thirty-five articles for the Standard Cyclopedia of Modern Agriculture, among which reference may be specially made to his original and valuable account of the Ayrshire breed of cattle, and his articles on Milk, the Construction of Byres, the Management of Dairy Cows, and his Calendar of Farm Operations for North Britain.

He was a man of remarkable vitality, energy, and capacity for work, and his knowledge of the details of agricultural practice both at home and abroad was unrivalled both in its range and minuteness. He was warmly interested in agricultural education, and for many years was identified with every public movement in Scotland for the advancement of agriculture. But perhaps the institution of the Ayrshire Milk Record Society, which was largely due to his efforts, may be regarded as the most valuable among his numerous acts of public service. [R. P. W.]

Spelt (*Triticum sativum spelta*), an old-established and popular variety of wheat which, while still important, has largely been replaced by other types of wheat. See WHEAT.

Spergula arvensis (Spurrey or Yawr) is one of the commonest annual weeds of light sandy land, in corn and root crops. It is closely allied to the common chickweed, but is readily distinguished by the narrow awl-shaped leaves arranged in opposite tufts. The plant branches from the root, producing numerous straggling, clammy shoots. Spurrey flowers from June to August, and produces globe-shaped capsule fruits containing flat seeds with a winged margin.

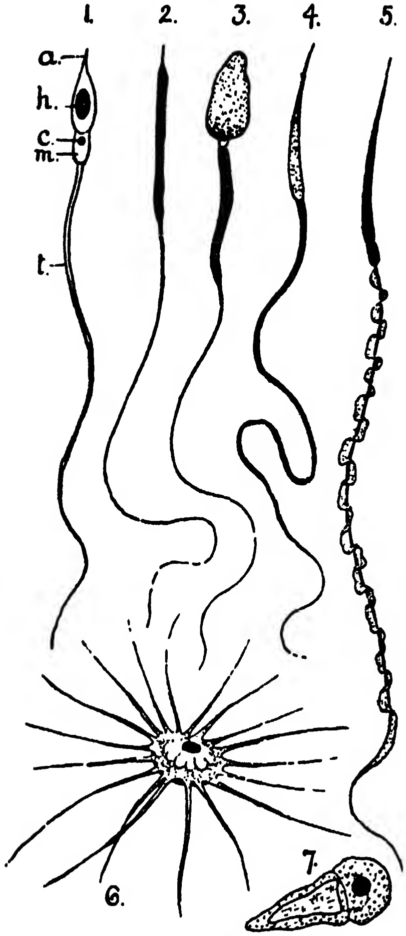
When this weed is plentiful in the corn, the yield of crop may be much reduced, but corn after lea is seldom injured by Spurrey. The root crop also may be seriously injured by this pestilent weed.

For eradicating, lime dressings are often efficacious, also spraying with a 5-per-cent solution of sulphate of copper applied at the rate of 50 gal. per acre. Hoeing and hand-pulling may at times be resorted to with advantage. As sheep readily eat Spurrey, the weed may be fed off with sheep, to prevent seeding in cases where the crop has been smothered by the weed.

A species of Spergula, namely *S. pilifera*, has

been recommended for forming lawns on very high sandy soils. This species retains its verdure during the hottest and driest seasons. [A. N. M'A.]

Spermatozoon, the male sexual element. Just as the female organism produces ova from



Various Forms of Spermatozoa

1, Diagrammatic. *a*, Apex; *h*, head with nucleus; *m*, middle piece with centrosome *c*; *t*, tail. 2, Earthworm. 3, Horse. 4, Pigeon. 5, Newt. 6, Crayfish. 7, Threadworm of horse.

the multiplication of germ cells in the ovary, so the male organism produces spermatozoa from the multiplication of germ cells in the testis. But there is a great contrast between the typical ovum and the typical spermatozoon in size and structure. The spermatozoon is very minute, a hundred or more may be borne on a pin's head. In many cases the spermatozoon is only $\frac{1}{100,000}$th of the size of the ovum, and if the ovum is swollen with yolk, which does not count as living matter, the spermatozoon may be less than a millionth of its volume. Moreover, while the mature ovum is quiescent, the mature sperm is usually adapted for vigorous locomotion. Much of its minute quantity of living matter forms a locomotor flagellum or 'tail', often of intricate structure, which drives the 'head' or nucleus before it, and at the junction of 'head' and 'tail' there is a short 'middle piece' or 'neck', in which there is often a minute body called the 'centrosome' or central corpuscle. The tail is altogether locomotor, driving the spermatozoon towards the ovum; the head contains the hereditary contributions from the male parent and probably some substance which stimulates the fertilized ovum to divide; the centrosome plays an important part in the division or cleavage of the fertilized ovum. It is a notable fact that although the ripe spermatozoon and the ripe ovum are very different, each has usually the same number of stainable bodies (chromosomes) in its nucleus, and that number is half that which occurs in the body cells of the animal in question. Thus when spermatozoon and ovum unite in fertilization the normal number of chromosomes is restored. Spermatozoa have very little reserve material, but they can live for days after emission from the male, whether in the oviduct of the female or when kept artificially in a weak salt solution. They always move against a current if there is one, and they are attracted to the ovum from a short distance. [J. A. T.]

Sphagnum (Bog Moss) is the botanical name for a genus of mosses common on every bog. The species are distinguished from other mosses by the brilliant yellowish-green colour when wet, and by the excessive whiteness when dry. They form wet sponge beds. The body of the plant is composed of a slender stem clothed with leaves. There are no root equivalents as in other mosses, the leaves having taken on the duty of absorbing the water. The leaf is of peculiar construction. It has no veins (*vascular bundles*); cells alone enter into its structure. These cells are of two kinds, the green and the colourless. The green cells are for manufacturing organic foodstuffs out of minerals, water, and air. The colourless cells are dead, and have spirally thickened walls and circular pores: their duty is to act as absorbing organs. Like their allies, these Bog mosses are endowed with powers of propagating extensively. But they can also reproduce sexually and form spores. The spore case is a globular body which opens by a lid to allow the spores to be scattered, and give rise to new generations of plants. Gardeners often use these Bog mosses for protecting the roots of flowering plants, and preventing them from drying: in the orchid house particularly, they are much in use. [A. N. M'A.]

Spices and Condiments.—These terms are applied to a large class of substances which possess aromatic and pungent properties. Some are entirely used in cooking, others as flavouring ingredients in medicine, while a third group —the essential oil-yielding seeds—have a place in perfumery as well as among the spices.

Very little of a definite nature can be learned, from official statistics, regarding the British supply of spices. The imports into the United Kingdom of 'cinnamon, ginger, pepper, and unenume-

rated spices' came, in 1908, to 30 million pounds, valued at £800,000 sterling. Of these quantities and values about half represent pepper, derived from the Straits Settlements, Madras, and French Indo-China, by far the most important being the supply from the Straits.

The following are the chief spices and condiments, arranged in the sequence of their better-known English names:—

1. ANISE (*Pimpinella Anisum*, Linn., *Umbelliferæ*); cultivated in Europe, Asia, and America. The seeds (fruits) are used in confectionery, in the preparation of cordials and in distillation, in the production of anise oil and anethol. The supply comes mainly from Russia, and in a less certain quantity from Germany, France, the Netherlands, Spain, Persia, India, &c. The distilled seed is dried and sold as fodder for cattle, for which it is valued on account of its high protein and fat content. The fruit of the 'Star Anise' (*Illicium anisatum*, Linn., *Magnoliaceæ*), a plant met with in China, also yields, on distillation, anethol. It is in great demand in the East as a condiment, and is used in Europe to flavour spirits, especially for medicinal purposes.

2. BETEL-NUT (*Areca Catechu*, Linn., *Palmeæ*), a cultivated palm met with throughout the hot damp regions of Asia, more especially the Malaya and India. It fringes the coast, and rarely extends more than 200 miles inland, nor ascends the hills to a greater height than 3000 ft. above the sea. Usually (in Southern and Western India and Burma) it is seen as a garden plant, two or three or perhaps as many as a dozen, mixed it may be with as many cocoanuts, surround the cottage or line the pathway that leads to the village tank. In Eastern and Northern Bengal, however, it assumes a position of greater importance. In certain districts of these provinces, regular plantations of 5 to 100 ac. in extent occur (exclusively of betel-nuts), and at such frequent intervals that they might almost be said to constitute a distinct agricultural feature, scarcely less important than the combined crops raised on the intervening tracts. In starting such plantations it is customary to plant them, in the first instance, with *Erythrina indica* (the *mandar*), a leguminous tree that doubtless enriches the soil. As time goes on the *mandar* is eliminated and the palms transplanted from the nursery to their final positions, until all that remains of the *mandar* is a hedge around the plantation. At this stage the palms may now be standing from 6 to 8 ft. apart each way, and as time goes on may be as much as 3 to 4 ft., many having by then been self-sown. It takes 30 years before such a plantation comes into full bearing, but it will continue to give a highly remunerative crop for 30 to 50 years subsequently, and necessitate practically little or no trouble or expense for all these years, other than to keep down weeds and supply a surface dressing now and again. The palms flower and fruit practically throughout the year, but the best results are from the flowers formed in January, which give their fruit in October, and from those in March, which fruit in December. Each palm will give two, or as many as four bunches a year; and if well cared for, and grown in suitable localities, especially with sufficient humidity in soil and atmosphere, each bunch may contain from 200 to 400 nuts. The nuts met with in trade vary extremely in quality, according to locality of production and method of preparation for the market. Usually they are simply collected, dried by exposure to the sun, shelled, and in that condition sold. In other instances the nuts are boiled whole or after being cut up into various-sized portions, and the fluid preserved and used again and again, thus colouring and imparting a uniform flavour to good and bad qualities alike, the boiling having the effect of destroying the obnoxious if not poisonous property of inferior or wild nuts.

The chief use of the betel-nut is as an astringent and stimulating masticatory. It is chewed along with the green leaf of the betel-pepper, a little lime, and flavouring spices—the mixture being known as *pân*. The importance of this nut in the Tropics may be inferred from the estimate of the amount annually paid by India alone for its supply, which has been returned as one-and-a-half million pounds sterling. In addition to India, Ceylon, the Straits Settlements, Sumatra, China, &c., are each largely interested in the production of betel-nuts.

3. BISHOP'S WEED (*Carum copticum*, Benth., *Umbelliferæ*). See CARAWAY.

4. CARAWAY (*Carum Carui*, Linn.). See CARAWAY.

5. CARDAMOM (*Elettaria Cardamomum*, Maton and White, *Scitamineæ*). See CARDAMOM.

6. CHILLIES (*Capsicum spp.*, *Solanaceæ*). See CHILLIES.

7. CINNAMON.—There are some twenty-four species of trees and shrubs placed in the genus *Cinnamomum* (of the *Lauraceæ*), and most of these yield barks which are sold as grades of the spice cinnamon or as adulterants for it. At least four are important, viz.: *C. Tamala*, Nees (Indian *Cassia lignea*, or Cassia cinnamon); *C. Cassia*, Bl. (the true or Chinese *Cassia lignea*), and *C. zeylanicum*, Breyn (the cinnamon proper). Lastly, reference may be made to another species of great interest, *C. Camphora*, Nees, from the wood of which Japan camphor is obtained. *C. Tamala* affords the leaves known in India as *tejpat*, which are used almost universally as a flavouring ingredient with meat, but are never apparently distilled for their aromatic oil.

The bark of *C. Tamala* and of *C. zeylanicum* (collected from the wild trees in the forests on the west coast of India) are sold as false or Indian *Cassia lignea*. They may be described as a coarse or low-grade cinnamon which is used as a spice and as a flavouring material in medicine, but it is the only cinnamon eaten by the natives of India, the true bark being alone sold to meet the demands of the Europeans.

The bark traded in in Europe as 'Cassia lignea' is obtained from China, very largely through Canton, and is derived from *C. Cassia*. The leaves and twigs are extensively distilled in the production of 'Oil of Cassia'. That oil is extensively employed as a perfume, especially in the manufacture of soap.

C. zeylanicum affords the true cinnamon of European shops. It is only in Ceylon that it is

now and has been for centuries cultivated on a large scale, on account of the aromatic bark. It grows best on sandy loams in sheltered situations within the Tropics. When a plantation is six years old the plants are cut down to the ground, and every alternate year thereafter are similarly pruned. In consequence, the plants acquire the habit of producing long willow-like shoots. These when cut off are trimmed, the leaves and lateral shoots stripped off, and a longitudinal slit from top to bottom made on each side through the thickness of the bark. The shoots are then rubbed with a smooth piece of wood, when the bark readily comes off. The strips thus obtained are then placed one within the other, packed into bundles, and set aside for a day or two. They are next once more opened out, the epidermis scraped off from each, then cut into lengths of about 12 in. and again placed one within the other, and left to dry in the shade. In consequence they gradually twist around each other and assume the condition, colour, and aroma of the quills met with in European commerce. The annual supply taken by the United Kingdom comes on the average to one million pounds, valued at £25,000.

8. Cloves (*Eugenia caryophyllata*, Thunb., *Myrtaceæ*). See Clove and Clove Trees.

9. Cocoanut (*Cocos nucifera*, Linn., *Palmeæ*). See Cocoanut.

10. Coriander (*Coriandrum sativum*, Linn., *Umbelliferæ*), a herbaceous plant cultivated in most warm temperate tracts. In India it is grown in the colder months of the year. In Europe it is a regular crop, as for example in Russia, Hungary, Holland, and even in England. It has been known from the most ancient times, and the seeds (fruits) used as a flavouring agent in food, confectionery, and in distillation, chiefly with gin.

11. Cumin (*Cuminum Cyminum*, Linn., *Umbelliferæ*), an annual herb of the warm temperate tracts, cultivated from the most ancient times in South Europe, Palestine, and India. It was a common flavouring spice in England during the 17th century, but has been displaced to a large extent by caraway. It is still extensively used in India and the East, is an important ingredient in many curry powders, and is often resorted to in veterinary medicine.

12. Cumin, Black (*Nigella sativa*, Linn., *Ranunculaceæ*).—This is sometimes called the Small Fennel or Fennel-flower Seed, and is an annual herbaceous crop. It is fairly extensively grown in all subtropical countries. The seeds are aromatic and yield two oils—a dark-coloured (fragrant and volatile), and a clear (nearly colourless, of the consistence of castor oil). The seeds are regarded as carminative and digestive. In India they are much used in curries, and are often employed by French cooks.

13. Cutch and Kath (*Acacia Catechu*, Willd., *Leguminosæ*). See Acacia; also Catechu.

14. Dill (*Peucedanum graveolens*, Benth., *Umbelliferæ*), the *sowa* of India, a glabrous herb cultivated since antiquity throughout the south of Europe, and in most subtropical countries of Asia and North Africa. It is frequently eaten as a vegetable, and from the seeds (fruits) an essential oil is obtained which has well-known medicinal properties and is extensively employed in perfumery, especially for soap. Both seeds and leaves are commonly used in India to flavour curries. In passing, it may be here added that *Peucedanum sativum* is the parsnip.

15. Fennel (*Fœniculum vulgare*, Gaertn., *Umbelliferæ*), a perennial which may attain a height of ' ft. It is cultivated in Central Europe, India, and Japan — bitter or medicinal fennel; Macedonia, France, Italy, &c.—sweet fennel. It is grown partly on account of the edible root of some forms, but more especially for the aromatic seed, employed both medicinally and in distillation. The oil is utilized in cordials and in the preparation of fennel water.

16. Fenugreek (*Trigonella Fœnum-græcum*, Linn., *Leguminosæ*), a robust annual herb, is cultivated extensively in the East, in Egypt, Abyssinia, &c. It is consumed as a fodder plant; the seeds are used in curries and as a condiment, and are of considerable importance in veterinary medicine.

17. Ginger (*Zingiber officinale*, Roscoe, *Scitamineæ*). See Ginger.

18. Kola (*Cola acuminata*, Schott and Endl., *Sterculiaceæ*). See Kola Nuts.

19. Nutmeg and Mace (*Myristica fragrans*, Houtt., *Myristicaceæ*). See Nutmeg and Mace.

20. Pepper (Black, White, Betel, Cubebs, &c.) (*Piper spp.*, *Piperaceæ*). See Pepper.

21. Peppermint (*Mentha piperita*, Linn., *Labiatæ*).—In Europe this is perhaps the best known of all the spices and condiments. Several species have been used for culinary and medicinal purposes from the most ancient times. *Mentha crispa* yields the *kraus-eminzol* of the Germans; *M. viridis* the American spearmint oil; and *M. arvensis* var. *piperasceus* the Japanese peppermint oil. What may, however, be called the true peppermint (*M. piperita*) is extensively cultivated in England, in America, Japan, Germany, France, Russia, and other countries. The cultivation of the plant, and the distillation of the oil therefrom, may be spoken of as important industries in the localities named. The English at Mitcham dates from the middle of the 18th century, but it has been in a languishing condition since 1850, when the American farms were started. It would seem, however, that the Japanese were distilling the oil for centuries before the art was known in Europe. In cultivation in Europe and America there are two chief forms, the Black and the White; but it may be said every locality has special stocks of its own, and that few plants respond to the influences of climate, soil, and treatment more readily. What is even more curious, several of these special races have distinct and valued chemical properties. The oil is largely used in medicine, cordials, and confectionery.

22. Pimento, Allspice, or Jamaica Pepper (*Pimenta officinalis*, Lindl., *Myrtaceæ*), a small tree (30 ft.) with a clean, white stem; wild in many of the West Indian islands, as also in Central and South America; cultivated on a fairly large scale in Jamaica for the sake of its unripe fruits—the 'Allspice' of these islands. The plantations of this spice-yielding tree are formed by

allowing plots of poor stony soils to lie fallow and get overrun with bush. A large percentage of the self-sown plants that thus appear is almost certain to be Pimento. In time the useless jungle plants are removed and the Pimento thinned out to, say, 20 to 30 ft. each way. Pimento succeeds on all poor soils, provided they are well drained, and exposed to a hot dry atmosphere. In about seven years the trees begin to give crops, the yield increasing for a few years thereafter as the plantation assumes maturity. The fruits are collected in a green state, in fact immediately the blossom falls. The ripe berries contain a sweet jelly, but have no aromatic property, and are in consequence valueless. The green berries are dried in the sun on trays, the drying process occupying from three to twelve days, according to climate. The proper degree of drying is recognized by the wrinkling of the surface, the dark colour assumed, and the rattling of the seeds within. In drying, the berries lose one-third of their weight, and the yield per tree may vary from a few pounds to a hundredweight. The name 'allspice' is suggestive of the aroma of these berries when carefully cured, namely the cinnamon, clove, and nutmeg all in one. The berries are largely used as spice in culinary purposes, and in medicine as a stimulating and flavouring ingredient. By distillation they yield 'Oil of Pimento', which in many respects resembles 'Oil of Cloves' and is similarly utilized.

The leaves of *Pimenta acris*, Kostel., are distilled in the production of 'Oil of Bay', a substance specially in demand in the manufacture of 'bay rum', which is used largely in the United States as a refreshing perfume in faintness. The dried unripe berries of that species also yield an inferior grade of Pimento. In Dominica the leaves both of *P. officinalis* and *P. acris* are collected, dried, and exported to the United States to be distilled. In Trinidad, oil of Pimento leaves is distilled and exported.

23. Turmeric (*Curcuma longa*, Linn., *Scitamineæ*), an interesting and valuable plant, which not only belongs to the family of the ginger, but in many respects closely resembles ginger itself. It is grown on account of its tuberous roots (or rhizomes), of which there may be said to be two main kinds, those used as a condiment and those as a dye. It is grown throughout the tropical regions of the globe. But as it got dispersed from its indigenous area the dye was confused with saffron. Cochin-china root is soft and globular, and usually comes into the European markets sliced. The Indian is hard, rich in dye, elongated, and comes entire. Hence the three grades, 'finger', 'bulb', and 'cut bulb'. The softer Indian 'fingers' are eaten as well as the 'bulb' forms. Turmeric may in fact be viewed as one of the most important of all condiments, being an indispensable ingredient in curry powders, imparting their most characteristic flavour as well as their colour.

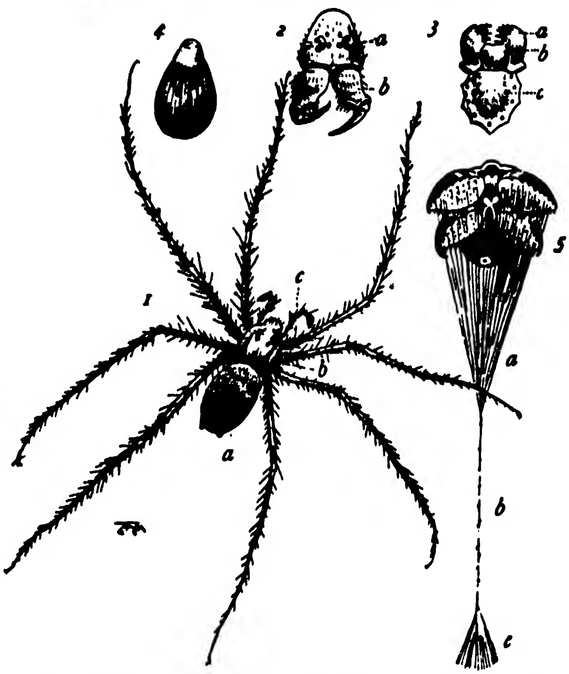
Turmeric requires a rich friable soil, and one above inundation level. It is frequently made to follow sugar cane, so as to participate in the liberal manuring that had been pursued. About April or May the land is raised into furrows, and the sets (root cuttings) planted on the top so as to be 18 in. or 2 ft. apart each way. About December or January the crop may be obtained, namely about 2000 lb. of fresh tubers to the acre. If left in the ground for a second year the yield will be both heavier and better. The tubers are cleansed, stripped of their fibrous roots, and stewed gradually in earthen pots. Then they are dried in the sun, the while being carefully protected from the dews of night. In some localities the tubers are boiled in water and dried, often by artificial heat. When intended to be used as a dye the tubers are boiled a second time, and while still wet are reduced to a paste and dried into the powder in which form they are usually sold. The dye is employed to give colour to varnishes, and in the production of certain compound shades often desired in silk and wool. The colour has a special affinity for cotton, but is fugitive. In European commerce, Formosan and Chinese turmeric take the first place, next come the Bengal, then that from Pegu, Madras, and Bombay. The price varies from 12*s.* to 26*s.* per cwt.

24. Vanilla (*Vanilla planifolia*, And., *Orchidaceæ*), a climbing orchid, the fruits of which (beans as they are called in trade) are employed as a flavouring ingredient in confectionery, ice creams, liqueurs, medicines, &c. On the conquest of Mexico the Aztecs were found to flavour their chocolate with vanilla, and in consequence the two products found their way to Europe almost simultaneously. A large demand soon thereafter arose for both, and cultivation of vanilla extended to Brazil, Honduras, the West Indies, Guadeloupe, Madagascar, Mauritius, Seychelles, Java, Fiji, Tahiti, Ceylon, and India. In its indigenous habitat (South-east Mexico) it is also now extensively cultivated, especially in Vera Cruz. Hence supplementing the wild supply, cultivation has greatly extended production, but has not lowered the price sufficiently to bring it into the universal demand that would otherwise be the case. The plant is grown against walls or on trellis work under broken shade. It requires a rich vegetable mould situate within the Tropics; but while it thus demands a hot damp atmosphere, the soil must be well drained, and even heaped up around the plants, to prevent surface accumulation of water. It is raised from cuttings several feet long, set at once in their final positions. It is a climber, and the fencing on which it is trained must be strong, for as the plants grow, it has to be linked up with transverse bamboos, from support to support, in every direction. In most of the larger plantations the main supports are live trees. In dry weather the soil should be mulched, so as to protect the surface roots; in fact the best dressing is fresh vegetable mould. Animal manures in any form should not be used. The plants commence to flower in their second year, and by the fourth the plantations should be in full bearing. In most of the countries of special cultivation, the insect or bird that accomplishes fertilization being absent, the planter has to instruct his servants in the process of fertilizing the fruits, and this has to be done in the morning of each day until flowering ceases. The fertilized fruit takes five months to attain maturity. If unfertilized, the

fruit turns yellow and drops off almost as soon as the flower. The flowers appear in February or March, in clusters of which less than half need be fertilized. The fruits are ripe when they begin to turn yellow; they should then be from 8 to 12 in. long and about 1 in. in circumference, and filled throughout their length with minute, black, oily seeds. The fruits must be picked by hand separately. If left until over-ripe they will split during the process of curing, and become next to useless; while if underripe they do not attain their proper aroma. On being brought to the curing house they are dipped into boiling water for a few seconds, then spread out on mats to allow the water to drain away, and afterwards are carried on mats to a place where they can be exposed to the sun. At night they are rolled up within their mats and placed within boxes to allow of fermentation taking place. This process of alternate sunning and fermenting is continued for a week or so, and, as it proceeds, the pods turn of a brown colour. They are the while carefully rubbed and squeezed between the fingers, and in some localities a little sweet oil is applied to them. If they show any tendency to split they are carefully tied up with string. Ultimately the drying is completed in the shade, this stage often taking weeks. The pods are then assorted according to length (the longer the better), tied up into bundles of twenty-five to fifty, packed into boxes, and often even soldered down so as to exclude the air and preserve the aroma. The fragrance is due to the presence of 'vanillic acid', which is often seen crystallized on the outside of successfully cured pods. In commerce, vanilla is the highest-priced vegetable, for its weight, that appears, but its characteristic active principle is closely imitated by a preparation of pine-wood oil and clove oil. It is moreover found in other species of orchids, though of a lower quality than that of the true vanilla plant. The inferior grades may be at once recognized by the shortness of the pods and their poor aroma. [G. W.]

Spiders belong to the section or order Araneidæ of the class Arachnida, which includes also scorpions and mites. They collect insects in various ways—some by hunting, others by watching in dark corners and holes and darting on their prey, very many by forming traps of webbing of various kinds. Spiders have all eight legs, and their head and thorax are united into one piece, the abdomen being distinct and baglike. They have simple eyes, in two, six, or eight arrangement. The mouth consists of modified mandibles with which the spider seizes its prey; the last joint of the falx or fang is curved, and fits into a toothed depression when in repose. This fang has a small aperture at the apex through which passes out a colourless, more or less venomous fluid secreted by the poison gland. At the moment of the bite the secretion of the gland flows into the wound, and in the case of small flies, &c., causes almost instant death. At the tail end of the spider are placed four or six wartlike structures, the spinnerets, through which the liquid that is to form the webbing is passed out, the various strands uniting into one piece of silk. The glue that forms the silk is secreted by glands in the abdomen; these open by fine pores on the surface of the papillæ. This silk is most elastic.

Spiders are divided into two sections: (1) the large, mostly tropical species, which have four



1, House Spider. *a*, Abdomen; *b*, cephalothorax; *c*, maxillary palpi. 2, Front of head. *a*, Ocelli; *b*, mandibles. 3, Under side of head. *a*, True jaw; *b*, lower lip; *c*, sub-mentum. 4, One of the air chambers. 5, Spinnerets. *a*, Minute web threads in moist sticky glue; *b*, threads stuck together with globules of glue which entrap insects; *c*, anchor of web.

air sacs and four spinnerets; the others (2), with which we are familiar in Britain, have only two breathing sacs and six spinnerets. The first are the Crab Spiders, or Mygalidæ, one of which, *Atypus sulzeri*, is found in Britain, a large spider which excavates a subterranean gallery with a silken tube. Amongst this group we also find the huge Bird Spiders (*Mygale*) and the Trapdoor Spiders. The Epeiridæ or 'Orb-weavers' are those we are most acquainted with in this country. They are humpbacked and globose, and form radiating, geometrical webs. The web consists of an elastic spiral line, thickly studded with minute globules of gum, and across this are drawn radiating fibres converging to the centre, which are devoid of the gummy drops. These sticky drops do not harden in the air, but the spiral thread is said to be renewed every twenty-four hours.

The majority of spiders lay their ova in masses surrounded with silk like a cocoon and in cases. Some carry the egg masses about with them. The young are like the adults, but are unable at first to catch their prey, and remain in colonies amongst the silk of the egg masses until after their first moult. The fine threads we find floating in the air in autumn, called gossamer, are the work of young spiders, which raise themselves in the air by this means. They pass the winter in sheltered positions. Most spiders hunt at night, but some of the wandering species do so during the day. The sexes are distinct, the males having a smaller abdomen than the females. The females often kill the males during or after copulation. [F. V. T.]

Spilonota roborana (the Rose Shoot Moth).—This small Tortrix moth measures about $\frac{3}{8}$ in. in wing expanse. The fore wings have a brown basal patch, a brown streak running along the costa to the middle, then white speckled with grey, tip reddish-brown, the spot or ocellus leaden-grey, edged internally with dark-brown. The moth appears in June and July. It lays its eggs on the rose shoots, and the larvæ feed in them; they are dull-brown with a dark head, and are found in April and May. It is very common, and harmful to roses. Nothing can be done for this rose pest save hand-picking the attacked shoots and burning them. [F. V. T.]

Spinach (*Spinacia oleracea*, nat. ord. Chenopodiaceæ), an annual cultivated for its leaves.

Spinach—Lettuce-leaved

Spinach is best suited by a deep, rich loam, which should be deeply worked and well manured. A somewhat moist and shady situation is to be preferred for summer crops, but in winter a dry position is advantageous. It is usual to make the first sowing in mid-February, to be followed by successional sowings every three weeks till May, and afterwards even more frequently till August, when the Flanders and Lettuce-leaved varieties are sown for winter use. Time is gained by soaking the seeds for a few hours before sowing; but if this is done they must not afterwards be allowed to become dry. The summer crop is sown in shallow drills about 1 ft. apart, and that for winter supply in drills 15 in. to 18 in. apart, or broadcast. The seedlings are first thinned to 2 in. apart, and afterwards to 6 in. or 9 in. Plenty of water is required in dry weather. The largest leaves should be picked off for use in preference to indiscriminate cutting. It is well to protect a portion of the winter crop by such means as putting up hurdles, or a row of stakes interwoven with fern or furze. Spinach may profitably be grown between rows of peas and beans or cauliflowers, and winter spinach to follow potatoes, or onions, or under fruit trees. The principal varieties are the round-seeded for summer, and Flanders, Lettuce-leaved, and Prickly-seeded for winter use. The Late-seeding or Long-standing variety may be sown for winter or summer use. [W. W.]

Spinach.—Parasitic Fungi.—The foliage may become blotched and discoloured. The fungus most commonly present is a whitish Downy Mildew (*Peronospora effusa*), which is also very frequent on White Goosefoot and other weeds of this order (see CHENOPODIACEÆ); from these weeds the Spinach becomes infected. *Treatment.*—Damage may be restricted by removing discoloured leaves, but plants badly attacked are best removed altogether. Neither Spinach nor Beet should be grown on the infected soil for some years, and a dressing of lime should be given. Diseased plants should not be used for seed production, as the fungus spores are carried in the seed husks. If Spinach is being raised under glass, ventilation is necessary, and wetting the foliage is to be avoided. [W. G. S.]

Spirit-level, an instrument for obtaining an exact horizontal line by means of a glass tube

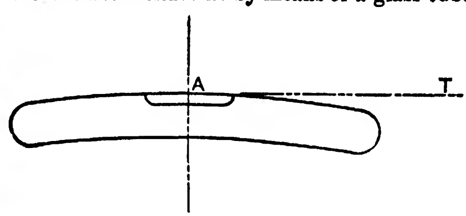


Fig. 1

(usually) containing some very limpid liquid and a bubble of air. The liquid most commonly used is alcohol, or a mixture of ether and alcohol, and the tube, which is hermetically sealed at both ends, is nearly but not quite cylindrical; the interior being ground so that a longitudinal section is slightly curved, convex upwards, as indicated in fig. 1. The air bubble, A, places

Fig. 2.—Pocket Spirit-level

itself at the highest point of the tube; and the tangent, AT, to the internal surface of the tube at the point is horizontal. The glass tube is usually fixed in a brass case, as shown in fig. 2, for convenience of handling and as a protection against fracture.

The horizontality of a line, to which a spirit-level is applied, is indicated by the air bubble being at the centre of its run; and when the bubble deviates from that position, the greater

the deviation the farther is the line 'off' the horizontal.

The term 'spirit-level', or 'level', is also applied to a levelling instrument used by surveyors chiefly for determining relative elevations of the ground, and of which the above bubble tube or spirit-level proper forms a part. There are various forms of level used in practice; the one shown in fig. 3 is Gravatt's, called the 'Dumpy Level'.

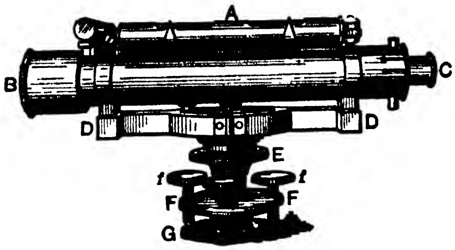
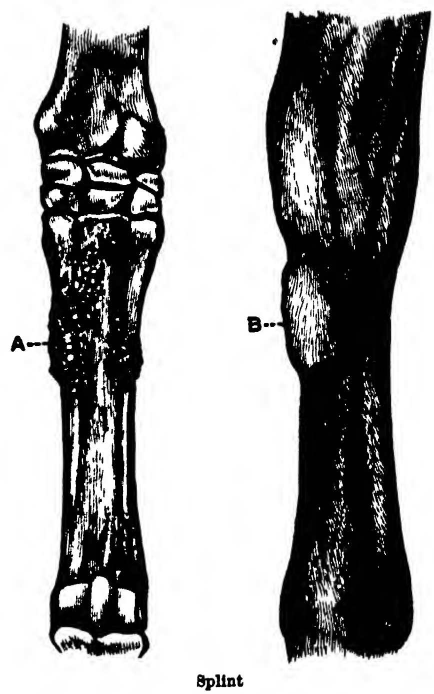


Fig. 3 —Dumpy Level

A is the bubble tube, attached by screws to the telescope, BC, resting upon blocks screwed to a flat plate or bar, DD. This bar is attached to a hollow cylindrical part, E, which turns upon a spindle fixed to the upper parallel plate, FF, the spindle being carried down to the plate, GG, and attached there to ball-and-socket joint. The four plate screws, *f*, are for the purpose of levelling the instrument, which, when in use, is carried upon a tripod. [H. B.]

Splenic Apoplexy, a name sometimes given to the disease better known as anthrax. See ANTHRAX.

Splint, a bony exostosis below the knee or hock and connected with the splint bones, which are placed on the sides of the metacarpal and metatarsal bones of the fore and hind limbs respectively. Splints are not confined to horses, but in these animals are of greatest importance because lameness is a frequent accompaniment during the formative period. Young animals, when first broken in or called upon to exert themselves, are the chief victims of splint, but certain conformations favour their development, as in the case of small-boned horses with long cannons. They may be regarded as natural stays or additional supports in many cases, and thrown out to provide against strain and concussion which the limb has found itself unable to bear. Their position on the limb is of great importance. The shape taken by splints is also to be considered in estimating the risks which their presence entails. If high up or near the knee or hock they may 'creep', as it is said, or grow in a direction which ultimately involves a joint, and so cause incurable lameness or anchylosis. If posteriorly placed, splints may interfere with the play of tendons or injure ligaments. A great variety of terms are employed by horsemen to describe the disposition and character of splints. Pegged or wedged refers to a growth of bony matter which passes between the little bones and the great ones, and is feared because the backward direction taken is in the space between the cannon and check ligaments and other soft structures capable of injury by rough surfaces which cannot be got at like those splints, which can be wholly traced on the side of the leg. As a general rule, the rounded variety are the least harmful if they are not so large as to present obstacles to the clearance of the foot of the opposite leg, and provided they are well forward. Splints originate in inflammation of the periosteal or bone-making membrane, and can be treated successfully by employing warm fomentations and cold lotions, and administering an aloetic ball while resting the patient. If this is done early, the splint is not likely to attain large dimensions, and we may presently excite absorption of its softer parts and the consolidation of the union between the bones by mercuric blisters (see BLISTERS). Failing early treatment, splints often grow to large proportions and necessitate severe measures, as puncture firing or scarification of the periosteum, or an operation by which they are dissected out. Many, indeed most adult horses have splints which have ceased to be a source of lameness or even of danger, and, provided their shape and situation are not bad, horses over five years old are generally passed by the veterinary examiner. [H. L.]



Splint

A, Exposed splint. B, Splint covered by skin.

Sport.—The word 'sport', although its meaning is sometimes extended to include all outdoor pastimes, is more usually applied exclusively to those recreations of which the main object is the killing of some animal. There has never been a time when Englishmen and Scotchmen were not devoted to sport. Indeed, the further we go back in history, the more important is the

part which sport appears to play in the national life; for what is now a mere recreation was often in earlier days a serious pursuit. When a man's life might at any time depend upon his skill with the sword, he was naturally assiduous in his study of the art of fencing. And we can easily believe that all the sports which partake of the nature of preparation for war awoke in the breasts of our bellicose ancestors an enthusiasm only inferior to that caused by the prospect of an invasion of France. When every man was a soldier, such an event as the historic fight between the Clan Quhele and the Clan Chattan at Perth on Palm Sunday, 1346, must have given rise to as much excitement as a modern 'cup-tie', or as the famous boxing championship between Corbett and Fitz-Simmons. Hence, too, the pomp and splendour of the great tournaments in mediæval times. And if the defensive and offensive sports have undergone this gradual decline into mere pastimes, the same must be said of hunting and shooting, and all those sports in which it is the sportsman's object to slay some quarry. For, apart altogether from the prehistoric age, there can be little doubt that in ancient Britain, sparsely inhabited as it was, hunting was often the means of providing a welcome addition to a sometimes precarious food supply. Hunting (see Hunting) was then not a recreation but a serious business. The transition was of course not sudden. For many centuries the chief objects of pursuit—the wild boar and the stag—were animals fit for the table; the final stage in the transformation of the sport may be said to have occurred when the inedible fox supplanted wild swine and deer in the affections of huntsmen—an event which took place only about 150 years ago. History relates the hunting feats of many of our early sovereigns, notably of Alfred the Great. Indeed, so enthusiastic and so selfish did the monarchs become, that hunting gradually became restricted to Royalty and to the greater nobles; cruel game laws were passed; and the barbarous measures which William the Conqueror adopted in order to create the New Forest are too well known to need description. All through the Middle Ages hunting never went out of fashion, and from quite early times—certainly since the 14th century—ladies appear to have played a prominent part in the sport. Queen Elizabeth, for instance, was a great huntress. It was not, however, until the middle of the 18th century that foxhunting began to come to the fore. Up to that time 'Reynard' seems to have been regarded, like his more formidable relative the wolf, as a verminly beast whom it was legitimate to destroy in any possible manner. It used to be held, moreover, that the pursuit of the hare (a sport which dates from much earlier times) affords a greater variety of interest than foxhunting. But after the wild boar had become extinct, which it did about 1620, and the opportunities for staghunting more and more restricted, the virtues of the vulpine tribe came to be better understood. Of course, in early days the mode of procedure was much more happy-go-lucky than now; the hounds were not always kept for hunting foxes only, and they were, indeed, often mere mongrels. There is no doubt, too, that both horses and hounds were slower than at the present day, and there was less hard riding. But the energy displayed by the huntsmen was great. The fox used to be routed out at an inordinately early hour, and it was actually the custom to breakfast at midnight. (See Foxhunting.) Except in the West country—with the famous Exmoor pack—and once or twice in Windsor Forest in George III's day, the wild stag has not been hunted in the British Isles since the 18th century. The people of Devonshire are not only favoured by the unique opportunity of hunting wild stag, but are also exceptionally well situated for enjoying the rare sport of otterhunting.

It may seem strange that the two greatest of our rural sports—foxhunting and shooting—should be quite modern innovations, but such is undoubtedly the case. Shooting came in at much the same time as foxhunting, namely, in the middle of the 18th century. It was only then that guns became sufficiently accurate to make it possible to hit birds whilst on the wing, and until that point of perfection was reached there could, of course, be no shooting in the modern sense of the word. There is no doubt that countrymen used to stalk game occasionally in much earlier times, as far back, indeed, as the 15th century, but the sport in those days must have been arduous in the extreme, for it was necessary for the hunter to creep up to within a very close range, and then take careful aim at the motionless and unsuspecting bird or quadruped. Although shooting became a regular and recognized pastime in the 18th century, the days of big bags did not begin until about 1840. The sportsman of the Georgian era would often go out for a whole day and tramp the country far and wide, perhaps getting a shot only about once an hour, and returning home in the evening with only two or three brace of partridges. Different, indeed, from the conditions prevailing at the present day! See Shooting.

Before firearms were of any use for bringing down flying birds, some other method—and a method more expeditious than the laborious and usually fruitless process of stalking the game—had to be found. And just as among quadrupeds the ingenuity of man utilized the natural instincts of the wolf tribe in order to secure venison and pork, so did he harness the powers of raptorial birds when he desired to stock his larder with feathered game. There are few sports more ancient than falconry. In England it has been practised from the earliest Saxon times, and abroad it seems to have been carried on in Babylonia as long ago as 1200 B.C., and in China in 2000 B.C. Although with the introduction and improvement of firearms the practical utility of falconry necessarily disappeared, the sport is still carried on in those parts of the British Isles where the country is sufficiently open to permit of it. Abroad, too, hawking is still in vogue, and perhaps the most remarkable of foreign achievements is the use which is made of the Golden Eagle in Central Asia. In that country the people train their eagles to hunt wolves; a quarry which, one would suppose, even

these great birds must find pretty formidable. The nearest approach to this in our own country is hare-hunting with the goshawk, the females of which species are powerful enough to hold the quadrupeds. The peregrine, the gyrfalcon, the merlin, the sparrow-hawk, &c., are also trained in Britain. See FALCONRY.

If mankind has succeeded in finding useful assistants in hunting terrestrial and aerial beings, in the case of fishes he has had to rely for the most part upon his own skill. Fishing is, of course, a much more ancient occupation than hawking, and may even date back nearly as far in prehistoric time as hunting. Nets have always been, and still remain, the most effective means of securing fish, but angling—that is, fishing with rod, line, or hook—has proved more attractive to amateur fishermen. Not that a considerable number of fishes may not sometimes be taken with a hook—especially in the case of sea-fishing. There are many parts of our coasts where bottom-fishing gives excellent sport, and the plenitude of game is often so great that the only difficulty is to haul in the lines fast enough. Freshwater fishing is of course a higher, if usually less fruitful, art. And again, angling with the fly is generally considered to take precedence of float-fishing. Angling under conditions essentially similar to those prevailing at the present day has been practised for centuries. As far back as the 15th century we read not only of rods, hooks, leads, floats, &c., but also of artificial flies. We may suppose, however, that our ancestors had lesser difficulties to contend with. There is no doubt that fishes inhabiting rivers which have been long frequented by anglers are not only less plentiful but much more wary. In many non-European lands the fish are so simple-minded that angling becomes almost child's play, and even in Britain the fishes in the Thames (which has been worked over more than any other river) are decidedly more cautious than their less persecuted congeners in other waters. See FISHING.

There is perhaps no British sport which is more wholesome and health-giving than seal-stalking. This can be enjoyed on many parts of our coast—which are frequented by both the Grey and Common Seal—but the best locality is the Orkney and Shetland Isles. Seal-shooting will appeal especially to the true sportsman, whose pleasure is enhanced by the presence of difficulties; for seals are remarkably wary creatures and are difficult to approach. They have to be shot whilst on shore, for they usually sink when killed out at sea. Another uncommon sport is badger-hunting. The mode of procedure is as follows: A number of men and dogs—any breed of cur will do, provided only they will give tongue—collect around the badger's hole at nightfall and watch until the creature issues forth from its lair. Then sacks with running nooses are placed in all the holes leading into the animal's subterranean dwelling, and when it has been given a good start the dogs are set upon its trail. An exhilarating chase then commences, and the 'brock' rushes back in hot haste to its home, only to find itself completely enveloped in a sack. The animal may be then turned loose once more in order to provide another run—indeed, the process may be repeated three or four times in one night—or it may be transported to another district to extend the range of the species. This method of hunting is most exciting, and since it has the additional merit of scarcely ever ending in a tragedy, it should certainly be more widely known and carried on than it now is. The fun that can be derived from a sport is not necessarily dependent upon the size and dignity of the quarry, and few pastimes are more full of perpetual excitement than ratting. It is, too, much the most effective way of getting rid of these vermin, for traps (see TRAPS FOR VERMIN and TRAPPING) and poison are not of much use—of less use in reality than the rat's natural enemies. Less care need be taken of the dogs than of the ferrets; almost any kind of terrier will serve, for they all have an ardent inborn love of the sport. For ratting, bitch ferrets are much better than the males, because owing to their small size they can follow their prey anywhere. They should on no account be muzzled, nor should they be run with a line. It is advisable to take a considerable number of ferrets and to let them hunt in turn; they almost always get wounded in the fray, and as a rat's bite is poisonous their sores should be dressed with sweet oil at the end of the day's work. White ferrets should be used; the brown ones are liable to be pounced upon by an over-hasty terrier, mistaking them for rats. [H. S. R. E.]

Spotted Flycatcher (*Muscicapa grisola*).—This inconspicuous migrant bird is fairly common in parts of Britain (less so in Scotland) from May to September. It is a little more than 5 in. in length, with fairly pointed wings and a very long hind toe. The rather stout beak is laterally flattened and very slightly bent down at the tip, while the broad flattened base is fringed by bristles, as in some other insect-eating birds. The male (in summer dress) is chestnut-brown above, with darker wings and tail, and grey below, while the throat is streaked or spotted. The plumage of the female is grey above and whitish below, like the winter dress of the male. The food consists entirely of insects of the most various kind, and the bird captures these on the wing, making short jerky flights from points of vantage. The Spotted Flycatcher is extremely beneficial to agriculture and allied industries, and it should be rigidly protected, and as far as possible encouraged. The five eggs are spotted with rusty or purplish spots on a greenish or bluish ground. There are two broods in the season. See FLYCATCHER, where a figure of this bird is given. [J. R. A. D.]

Sprains. — When more force is exerted upon a tendon, ligament, or muscle than it can bear without injury, it is said to be strained or sprained. Tendons and ligaments are not elastic, and only become elongated by continuous force. Strains vary from a slight extension to partial rupture or breaking away of fibres. Complete rupture passes out of the category of sprains, although accomplished in the same manner. The soft swelling which follows on a strain is due to the presence of extravasated blood or

exuded lymph; and this prevents the immediate reunion of ruptured fibres, although ultimately contributing to repair. To hinder the accumulation of these matters and provoke their absorption is our primary object in treatment. Either hot or cold water checks the circulation of the blood, and so hinders effusion into the tissues. Purgatives and diuretics carry off more or less of the effused fluids. Fluidity of the blood by copious draughts of water should be maintained. Laxative foods favour the subject of sprain. Whether to rest or use a sprained structure is still a moot question. The generality of veterinary practitioners prescribe rest, and special appliances, such as high-heeled shoes, to relieve sprain of legs; also cold or evaporating lotions, and, later, warm liniments or stronger agents as blisters, and a turn out at grass. Many sprains are cured by a thick layer of cotton wool compressed by bandages. [H. L.]

Sprayers.—Sprayers distribute liquids in the form of finely divided sprays over fruit trees and farm and garden crops to prevent or destroy injurious insects and fungi. In almost all instances an air-tight vessel containing the liquid is supplied with an air chamber in which air is compressed by a pump, so that as it passes out of the nozzle the liquid is formed into a fine spray. Occasionally, as in the Strawsonizer, the liquid is broken up by means of a strong blast which impinges upon it as it is fed out. The finest spray is made in this way, 2 gal. of paraffin being made to form a complete film over an

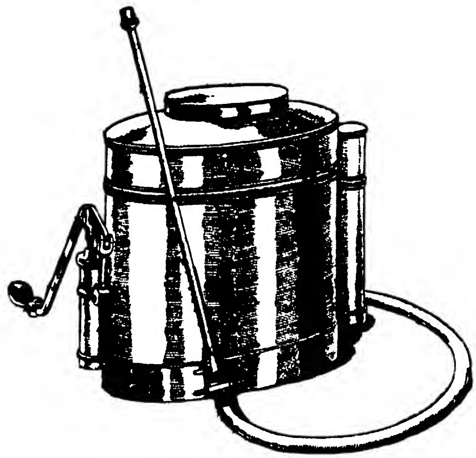


Fig. 1.—Four Oaks Knapsack Sprayer

acre. In this, rubber, which is quickly destroyed by paraffin when used in other forms of machine, is not required. Sprayers may be classified as

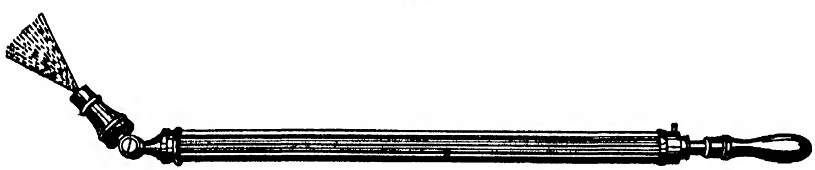


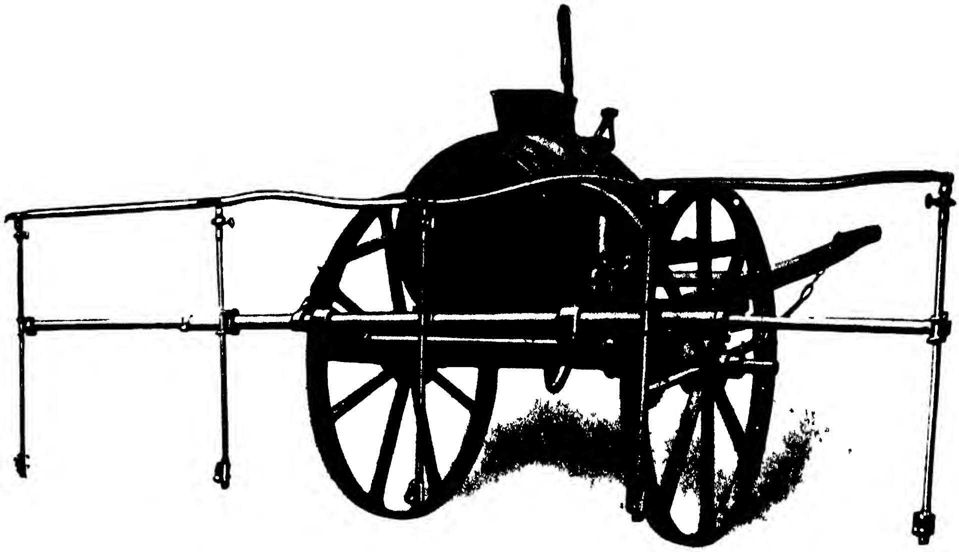
Fig. 2.—Four Oaks Angle-Jointed Spraying Syringe

hand syringes, knapsack, portable or wheeled with hand-pump attachment; horse-drawn cart with hand pump; horse-drawn machine with geared pump; horse-drawn machine with petrol-driven pump and air blast.

Syringes are squirts with variously shaped nozzles, suitable only where small areas are treated. The knapsack is suitable where a moderate area is to be treated. Until recent years a diaphragm pump was exclusively used; but recently machines having a small pump fitted to the outside of the container, with an outside air chamber, as in the Four Oaks Sprayer, have been introduced, and though rather more expensive, are more effective and in all ways better than the diaphragm. No stirrer is needed, as at each stroke a jet is forced from the bottom, so there is no inside attachment.

The recognition of the value of spraying with a solution of sulphate of copper to destroy charlock, and with the Bordeaux mixture or its equivalent to prevent potato disease, called for machines capable of dealing with a big area. This was met by Swanson's machine, which worked a series of nozzles connected by rubber tubing, through which the solution is forced, a pump being worked either by hand, as when the barrel or container is placed in a cart, or from gearing where a self-contained machine is used. Charlock spraying and potato spraying can be performed by the same outfit; but where the latter is done, the nozzles are fitted to fauces suitably contrived to allow the spray to be driven upwards between the rows of potatoes. In working these machines a pace from 2 to 2½ miles an hour is most suitable, and uneven paces should be avoided. Fruit-spraying machines are required to be able to deal with thicker solutions as well as with thin solutions. The same machines are used for lime-washing buildings, &c. (see LIME-WASHING MACHINE). For hops, specially long tubing is necessary (see HOP-GROWING MACHINERY). [W. J. M.]

Spraying.—Although the spraying of hops for the destruction of the aphis has been carried on more or less extensively for a great number of years, that of potatoes, charlock, and fruit is of comparatively recent introduction in this country. Even in the case of hops the operation has increased greatly in prevalence and persistency. Quassia extract and soft soap are still the ingredients of the wash most commonly applied to hops, although there are numerous proprietary mixtures which are used to a considerable extent. Powerful machines, worked by horse or steam power, are commonly used



MIKADO FIVE-ROW SPRAYING MACHINE ADAPTABLE FOR SPRAYING EITHER CHARLOCK OR POTATOES

CHARLOCK-SPRAYING BY HAND POWER FROM AN ORDINARY FARM CART

in the spraying of hops. Sulphuring for the prevention of mould is equally necessary in most seasons.

The spraying of potatoes with Bordeaux mixture, consisting of copper sulphate and lime, is a modern practice. The mixture was first used for vines in France, and it was not till 1888 that M. Girard began to experiment with it for the prevention of the common potato disease, *Phytophthora infestans*, while it was about twelve years later before the remedy was introduced in England. For potatoes the constituents are 20 lb. of copper sulphate and 10 lb. to 20 lb. of quicklime to 100 gal. of water. Special machines for distributing the mixture were brought out some years ago by Mr. G. F. Strawson, of Queen Victoria Street, London, one as an attachment to a farm cart, and another as an independent machine. At least two sprayings are desirable, and the first should be applied as soon as the crop has gone off blossom, while the second may take place two or three weeks later. The mixture is not a complete preventive, but it reduces the extent of the disease.

The value of copper sulphate for the destruction of charlock was discovered by accident in France. Some spare solution of it or of Bordeaux mixture used for vines, was thrown on the ground where some charlock and other weeds happened to be growing. These, or some of them, were turned black and killed by the solution, and it was then suggested that, if it proved harmless to corn crops, charlock growing among them might be destroyed. In 1898 a public trial of spraying charlock with a solution of copper sulphate alone was conducted by Mr. Strawson near Chelmsford. It proved successful, as also did subsequent trials, and the practice of spraying fields of corn infested with the troublesome weed speedily became common. A 3-per-cent solution, that is, 30 lb. of copper sulphate to 100 gal. of water, has been generally used, but some prefer a 4- or even a 5-per-cent; and it was found that when properly sprayed in the form of a fine mist, so as to cover every leaf of the weed, 50 gal. per acre are sufficient. See art. MUSTARD WEEDS.

Even more remarkable than the progress of spraying against potato disease and charlock is the application of the operation to fruit crops. It was systematically practised in the United States long before it was tried to any considerable extent in this country. The work of the late Miss Ormerod, by calling attention to remedies for the great damage done to fruit trees and bushes by certain insects, was largely instrumental in extending the operation of spraying in our fruit plantations. More recently the publication of the results of experiments carried out at Woburn by the Duke of Bedford and Mr. Spencer Pickering has further extended it. As evidence of the rapid progress made in this direction, it is enough to state that for one firm offering various kinds of spraying materials in 1905, there were at least a dozen candidates for the custom of fruit growers in 1910. Similarly there has been a great increase in the production of spraying machines in different forms.

A description of a season's spraying campaign as pursued by an up-to-date fruit grower will be the most convenient method of noticing the operations carried on for various purposes. Except when the plan of spraying apple trees for the destruction of egg-laying aphides is carried out in the autumn, the first operation may be said to be that of spraying gooseberry bushes and possibly plum trees with a lime-and-sulphur wash, to prevent birds from eating the buds. If rain washes the stuff off, the operation may have to be done a second time. Next there is spraying apple trees with some caustic wash, either in February or later, to destroy moss and lichen, to kill woolly aphis and various hibernating insects, and if possible to destroy eggs. The possibility of destroying the eggs of insects by any wash known at present is denied by some authorities; but some fruit growers claim that they have prevented infestation by the apple sucker (*Psylla mali*) and the aphis by means of a lime-and-salt mixture. A wash to be applied when trees are dormant, in February for choice, is one composed of lime, sulphur, and caustic soda, which is effective for all the purposes just named, with the possible exception of the destruction of eggs, while it has the further advantage of acting to some extent as a preventive to scab. For the last-named pest alone, however, a weak solution of copper sulphate, 4 lb. to 100 gal., applied shortly before the buds burst, is more certain to prove effective. Caustic washes are not commonly applied to plum trees; but if the lime-and-sulphur wash, without caustic soda, should not be needed to prevent birds from eating the buds, it may still be valuable for plum trees as a preventive to certain fungus diseases.

As soon as any aphides are noticed on apples or plums, one of the numerous washes for their destruction should be promptly used; for when the leaves have curled over the pests, they are protected from any application to a great extent. Various nicotine or paraffin preparations are now sold for this purpose, but it is questionable whether any of them are superior to the old mixture of quassia and soft soap. When there is a bad infestation, spraying for aphis has to be repeated two or three times. The same operation is destructive to the apple sucker, which, like the aphis, can be killed only by contact, as no poison affects the food of a sucking insect, which is the sap of the infested tree.

When the blossom of apples has fallen, spraying with a poison, lead arsenate for choice, is important, to kill the larvæ of the codlin moth and various leaf-eating caterpillars. With this wash it is now usual to combine Bordeaux mixture, as a preventive to scab. For fruit it is important to avoid a strong Bordeaux mixture, as the foliage is liable to be scorched thereby. Not more than 8 lb. of copper sulphate, with lime to neutralize the acidity, should be used, at least when the foliage is tender, and 6 lb. would be safer. Usually the application has to be repeated about a fortnight later, or, if caterpillars are not then troublesome, Bordeaux mixture will be needed for scab, where that highly destructive disease is prevalent. Indeed, where it is bad among apples or pears, a third spray-

ing is to be recommended. Brown rot (*Sclerotinia fructigena*) and powdery mildew (*Sphærotheca mali*) among apples will be encountered also by these sprayings against scab. For brown rot among plums and cherries a similarly weak Bordeaux mixture should be used. For aphis on currants, the spraying referred to in connection with apples and plums will serve equally.

It is important to bear in mind that in spraying Bordeaux mixture and poisonous washes a very fine mist should be aimed at, avoiding such a drenching as would make the trees drip. In treatment for aphis or apple sucker, on the other hand, a thorough drenching is desirable, and in the application of a winter wash every part of a tree or bush should be well wetted.

[W. E. B.]

Springbuck, or **Springbok** (*Antidorcas marsupialis*), a genus of South African antelopes closely related to the gazelles, but distinguished from them by the suppression of the anterior lower premolar, so that there are only two instead of three of these teeth in the mandible, by the reduction in size of the corresponding upper premolar, and by the presence on the hinder part of the back of a conspicuous white blaze susceptible of being displayed or concealed at will. Horns are present in both sexes, and are much smaller in the female than in the male, being lyrate with incurved points in the latter, and averaging about 15 in. in length. The general colour is brown or sandy-fawn on the neck, body, and outsides of the limbs; the belly, rump, and tail, with the exception of the black tuft, being white. The white of the rump, which is continuous over the croup with the dorsal blaze, is margined with dark-brown, and a conspicuous broad dark-brown stripe similarly borders the white pervading the belly. The face also is mostly white in the adult, but a brown stripe extends on each side from the horn across the eye to the corner of the mouth, and there is a larger or smaller brown band on the forehead and nose, which becomes reduced in extent with advance of age. The height is a little over 30 in. The period of gestation is nearly six months, and the young, one or two in number, are born in November. The Springbuck is the only member of the gazelline group which occurs in Africa south of the Zambesi, where it is still met with in the arid districts of the Transvaal, the Orange River Colony, Bechuanaland, German South-west Africa, thence northwards to Mossamedes, and in Cape Colony from Namaqualand in the west to Queenstown in the east, and as far south as the Zwartberg ranges forming the southern boundary of the Karoo. The scientific name *marsupialis* was given to this species in allusion to the presence of the dilatable fold or pouch of skin which, when spread, constitutes the dorsal 'blaze' so characteristic of this animal; and the popular name Springbuck is derived from its habit, when playful or disturbed, of leaping high into the air, as it moves away, with head bent down, back curved, and legs held extended, stiff and close together, bounding from the ground to a height of 10 or 12 ft., as if its legs were resilient steel springs and covering without the least appearance of effort a distance of 7 or more yards. In former years these buck occurred in herds consisting literally of hundreds of thousands of individuals; but although their numbers have been greatly reduced since the introduction of firearms into South Africa, they still exist in vast multitudes. A portion of a migrating herd was computed in 1896 to be composed of at least 500,000 animals. It is for their remarkable migratory habits that Springbuck are most notorious. Vast hordes of these antelopes, or *trek bokken* as they are then called, periodically pour down into the fertile districts of Cape Colony, destroying every blade of grass or growing corn in their onward march, devastating wide tracts of country and inflicting incalculable loss upon farmers.

[R. I. P.]

Spring Cultivation.—This expression is often employed in contradistinction to autumn cultivation, and in such cases refers to the preparation of land for roots. This, indeed, seems to be the sense in which it is generally understood; but it has also a wider significance, and may include the cultivation of spring corn, or of clover and grass seeds. In the following remarks the former aspect is chosen, and it alone will be discussed pro and con. Spring cultivation has always been general, but most writers exhibit a preference for autumn cultivation to the partial exclusion of spring tillages. Much depends upon the class of land to be operated upon, and all medium soils may be cultivated in spring without incurring the risks of either depriving them of moisture or of producing a hard and intractable surface. The objections to the system are most evident upon very heavy and very light land, and on such soils a more thorough pulverization in the one case, and a better conservation of moisture in the other, are effected by autumnal cultivations. Much also depends upon the period at which the work is performed, for winter ploughing may be carried on up to the end of February, without producing any ill effects; and March frosts are often relied upon to produce a tilth. The objections to spring cultivation are chiefly confined to late ploughing, after which drought may rob the land of its moisture, or produce a cloddy surface, difficult to reduce to the necessary fine condition for root sowing. The system of deep ploughing in autumn has been highly recommended, to avoid the above evils; and spring cultivation for roots should, it is thought, as far as possible, be confined to the use of cultivators, grubbers, rollers, and harrows. This is no doubt sound teaching, but most farmers, in spite of all that has been advanced on the subject, cling to the plough as the most thorough form of cultivating implement, even in spring. The writer will never forget the dictum of a Merse farmer in Berwickshire. 'Some', he said, 'use the cultivator and grow thistles!' Again, an Essex agriculturist once remarked: 'If you don't plough, you lose mould'. A *via media* is probably the best, and may be summed up as follows. Late spring ploughing is often injurious to the future root crop, both on heavy and light soils; and frequent ploughings in spring are bad. On the

other hand, one extra ploughing in late winter or early spring is good farming, and afterwards the land is better allowed to 'gather moisture' by capillary attraction from the air and the subsoil, while the surface is mellowed and pulverized by atmospheric changes. It will be seen that the controversy as to spring cultivation for roots is chiefly centred around the use of the plough; and this is due to the plough alone of all cultivating implements inverting the soil, thereby burying the fine surface produced by frost, and promoting evaporation of the soil moisture. [J. WR.]

Springs. See WATER, UNDERGROUND.

Spring-tails, a group of apterous insects which, on account of their skipping motion, are called Spring-tails. See art. COLLEMBOLA.

Spring Wheat. See WHEAT.

Spruce (Picea) is a genus of the Abietineæ tribe of the nat. ord. Coniferæ. It is an evergreen tree with single leaves ranged spirally around the twigs and persistent for several years, and with cones ripening in the year of flowering. Hemlock is the genus having the closest affinity and resemblance to Spruce; and in both the older defoliated twigs are rough with prominent leaf-scars, and the seed-bracts are short and completely hidden by the cone-scales. But in Spruce the leaves are sessile, 2- or 4-sided with two lateral resin-ducts, and ranged along the upper and under sides, and the cones are usually large; while in Hemlock the leaves are petiolated, 2-sided with one resin-duct running along the back of the leaf, and the cones are usually very small. Spruce is easily distinguishable from Pine by its smooth red-brown bark, its pyramidal form, its foliage, its cones, its thinner and more elastic branches, and its growth in closer canopy. Only one species of Spruce is indigenous to Europe, the Common or Norway Spruce (*P. excelsa*), introduced into Britain about 1548; while other species found here include the Menzies or Sitka (*P. Sitchensis*), introduced in 1831, the White (*P. alba*), the Blue or Prickly (*P. pungens*), and the Black (*P. nigra*), from North America, the Himalayan (*P. Morinda*) from India, the Sapindus (*P. orientalis*) from Asia Minor, and Alcock's (*P. Alcoquiana*) from Japan. Of these only the Common and the Menzies Spruce are ever likely to prove profitable in British woodlands; and the Common species seems to deserve the preference, though the Menzies is the more rapid in growth during the first five or six years after planting. They are easily distinguishable, as the Menzies Spruce has shorter and lighter-coloured foliage, which is shed in the second year; while the Common Spruce has thicker and darker green foliage, which persists from four to six years (according to the soil and the situation), and larger cones. Its finest development is on the mountains of Northern Germany, north of the Silver Fir region, and it forms large pure forests in Scandinavia and Russia. It grows well and rapidly in Britain, and especially in the cool damp climate of the West of Scotland; but unless kept in close cover the side branches form large knots depreciating the value of the timber. Grown in an isolated position it remains clothed with foliage down to the ground, and forms a very picturesque object. At Studley Royal (Yorkshire) a specimen measured 132 ft. high and 12½ ft. in girth in 1891. The wood is white, soft and light, much resembling that of the Silver Fir, though slightly yellower in colour. It does not take creosote well. It is largely imported from the Baltic as 'White Deal' (in contradistinction to the 'Red Deal' of Scots Pine). Both in Europe and in America Spruce is now the chief wood used for making pulp and cellulose; but only smooth, closely-grown poles, free from knots, can thus be utilized. In Germany it is considered one of the most profitable timber crops that can be grown; and there it is generally worked with a rotation of from 80 to 100 years. It is a shallow-rooting tree, suitable for planting on a fresh or moist soil too shallow for other firs or for pines; but it thrives best on a sandy loam. Judging from the diminishing supplies of this useful tree in easily accessible localities, and the growing demand for its timber as pulp wood and for constructive purposes, it should probably prove one of the most profitable trees to grow in large masses in the hilly tracts of Britain. Though shallow-rooting, Spruce can stand well against storms if the outer edge of the wood has free room to develop towards the windward side. It therefore makes a good wind-screen or protective fringe in hilly tracts with soil suiting it (though White Spruce is in some cases preferable). Spruce produces seed freely every two or three years from about 30 to 40 years of age onwards. The cones should be gathered in autumn and stored during the winter. One pound contains about 64,000 seeds, and gives from 30,000 to 40,000 seedlings, which are hardy against frost. Transplanted as 2-year seedlings, they can be put out at 4 by 4 ft. when 2-year-2, or 2-year-3 if large plants are needed. Owing to its high crown of thick foliage and its shallow root system it is seldom regenerated naturally, clear-felling and replanting being the usual method of renewing mature Spruce woods. At first the Common Spruce is not of such rapid growth as Menzies Spruce, Larch, or Scots Pine; but, unless suppressed, it catches up and shoots ahead of these last two during the early pole-stage of growth. When planted along with and suppressed by other quicker-growing and light-demanding trees, it forms good shelter and cover for game. A shade-enduring tree with a conical compact crown of foliage, it forms thick woods, though the total contents per acre are not so large as the yield of the Silver Fir. Unless kept in close cover the stem does not clean itself well from branches, and the danger of windfall then becomes greater. In Britain it seems less suitable for underplanting in Oak and Larch woods than Silver Fir or Douglas Fir, although largely used thus in Germany. Spruce poles and logs should be removed from the woods before the end of May, or else barked, otherwise they form breeding places for bark-beetles which can easily spread to sound trees, doing much damage and being difficult to eradicate. Careful tending is necessary at all stages of growth, as Spruce

(like Scots Pine) is liable to attack by many noxious insects and fungous diseases. In common with other conifers, young plantations of Spruce are apt to be attacked by the Pine weevil (*Hylobius abietis*) and the small brown weevil (*Pissodes notatus*). [J. N.]

Spruce.—Parasitic Fungi.—The following are the more destructive fungi occurring on Norway Spruce and other species of Picea.

SEEDLING DISEASE.—Considerable damage may be done amongst seedlings, especially if the plants are crowded or overgrown with weeds, and so kept in a moist condition favourable to those fungi which attack seedlings of conifers. See PINE—PARASITIC FUNGI.

LEAF CAST.—Plants, after the seedling stage, frequently show premature shedding of leaves accompanied by one or other of the following fungi. *Septoria parasitica* attacks the base of young shoots so that they hang down and the leaves wither. Yellow blotches on the needles are caused by Ascomycete fungi (e.g. *Lophodermium macrosporum*). Several of the Rust fungi also attack the foliage of Spruce, and the cluster-cups of other species appear as rust-patches on the cone-scales, so that no seed is produced.

STEM ROT.—*Agaricus melleus* and *Trametes radiciperda*, both of which effect an entrance through the roots, are as destructive to Spruce as to other conifers. (See PINE—PARASITIC FUNGI.) The timber may also show white or red rot resulting from the activity of wound fungi, especially various Polypores. In some localities much destruction is caused by stem canker due to *Nectria cucurbitula*, nearly allied to apple canker (see art. TIMBER-DESTROYING FUNGI). [W. G. S.]

Sprung Hock.—This malady, which occasionally occurs in horses, is treated fully in the art. HOCK, SPRUNG.

Spurge (Euphorbia) is the common name for a genus of annual or perennial weeds belonging to the nat. ord. Euphorbiaceæ. All the species are poisonous, containing abundance of acrid milky juice. The other characteristic feature is the three-cornered and three-lobed seedvessel rising on a stalk from the middle of a green cup in which the stamens are almost hidden. The Sun Spurge (*Euphorbia helioscopia*) is a common annual species on light land. It is erect and diminutive, only 6 to 12 in. high, with serrated leaves 1 to 2 in. long, broad and obtuse at the apex and narrow at the base. For extirpation, clean cultivation and prevention of seeding are effective. The seed of Sun Spurge sometimes occurs as an impurity in farm seeds. It is recognized by its oval outline, by rolling on a smooth surface, by the netted skin, and by the white, kidney-shaped, very conspicuous scar at its base. [A. N. M'A.]

Spurrey.—This troublesome weed, so common among cereals and root crops, is described under its botanical designation SPERGULA.

Squash.—This name is given (as also Gourd and Pumpkin) to a number of species and varieties of plants belonging to the Cucumber family. Being natives of warm climates they cannot be sown outdoors in this country till May, and they are killed by the first frosts in autumn. The Vegetable Marrow is the only Squash generally grown in England, but a number of them are much esteemed in America, and to a lesser degree in France, and they deserve more attention from gardeners here. They should be grown in holes filled with manure, with 6 in. of soil on top. Extra large fruits are obtained by allowing only two or three on each plant to develop; and it is a good plan to regulate the growth by pruning, and to throw soil over the stem joints here and there, when they will send out roots. Some varieties are eaten raw like cucumbers, others are cooked in a number of ways, notably in the American form of pies, and they have the good quality of keeping for a considerable time after being cut. The following are some of the sorts most deserving of cultivation: Canada Crook-neck—excellent for the late crop; the fruits may be preserved till the following summer. Egg, Apple, and Orange Gourds—these are very ornamental plants when grown on poles; the fruits are eaten in a young state. Green-striped Bergen—very hardy, and used both in the green and ripe state. Harrison's Pumpkin—said to be capable of producing 50,000 lb. of fruit per acre. Italian Vegetable Marrow—of compact bushlike form; best when eaten in the young green state. Mammoth Pumpkin—the fruits of which keep well, and have been known to weigh more than 200 lb. Hubbard Squash—a favourite American kind; and Winter Crook-neck—very prolific, and largely grown for autumn and winter use. [W. W.]

Squirrel (Sciurus), arboreal rodents distributed all over the world except in the Australian region. The Common Squirrel (*S. vulgaris*) is an active animal with a slender body about 8½ in. in length, and a very bushy tail which measures nearly as much as the body. The fore limbs are shorter than the hind limbs; the feet are adapted for climbing; the eyes are large and prominent; the ears are pointed, and are usually tufted, the tufts growing very long in winter and disappearing for a time in early summer. The general colour is reddish-brown slightly intermingled with grey on the upper parts, and white underneath. The squirrel is now fairly common in wooded districts throughout the greater part of Britain, but towards the end of the 18th century it had apparently become extinct over a large part of Scotland. Towards the middle of the 19th century it reappeared in Sutherlandshire, and with the planting of young timber soon spread to the neighbouring counties and multiplied rapidly. The squirrel makes 'the best nest of any mammal'. It has a foundation of sticks, on which is placed the nest proper, made of moss, grasses, leaves, curiously interwoven. A sloping roof affords protection from rain, and the main entrance is usually directed downwards. Three to seven young ones about the size of mice are born early in April. They are blind and helpless at birth, but are able to leave the nest within a fortnight. A second litter may be born in June, and the whole family is said to keep together throughout the summer.

The food of the squirrel consists mainly of nuts, acorns, beech mast, and unfortunately also the bark of young branches and tree-tops. It is, however, not exclusively vegetarian, for it eats beetles and grubs, and plunders birds' nests, devouring both eggs and young birds. Though it becomes drowsy in cold weather, it does not hibernate completely, but comes out frequently to feed on the stores of nuts and the like which it has hidden in different places. The squirrel is very destructive to woodlands (see succeeding article). On the other hand, the squirrels are a most effective check to the excessive multiplication of wood pigeons. The fur of the squirrel is used for lining cloaks, for making 'camel's-hair' brushes, &c. [J. A. T.]

Squirrels—Damage to Woodlands.—Squirrels may do very serious damage, and especially in coniferous woods. They feed on most kinds of tree seeds, but are particularly fond of acorns, and beech and hazel nuts; they eat the flowering buds of Oak, Beech, Maple, Sycamore, and Conifers in late winter; and in summer and autumn pick cones to pieces, even before these are ripe, to suck the juice and eat the seeds. Hence seed production is poor wherever squirrels are numerous. But the greatest damage they do is when, during spring and summer, they seat themselves on the branch whorls of conifer poles or trees and gnaw the soft bark, often completely girdling the stem, which then dies, rots, and ultimately falls off. In the North of Scotland so much damage of this sort has been done, especially in Scots Pine and Larch woods, that the landowners in Ross, Cromarty, and neighbourhood had to form squirrel clubs for shooting and trying to exterminate this pretty, but excessively destructive pest; and over 15,000 were shot within five or six years. They are very destructive in some parts of Ireland, where they are said to have been introduced about fifty years ago by two boys letting loose a pair given to them as pets. Trapping is less effective than shooting, and the best time for this is during the nesting time in May, when a charge of small shot will kill both mother and brood. Where squirrel raids are not permitted during the nesting season, the best time for shooting them is in February, before the game birds begin to lay. [J. N.]

Stable.—The position of the stable should be carefully considered with relation to the cart shed, the straw barn, and immediate access to the main roads. The height of the walls should in no case be less than 8 ft., and 9 ft. is preferable in order to give sufficient headroom at doors and windows. The width of stable should in no case be less than 18 ft. inside, and each stall should be not less than 6 ft. wide. The inside walls should be smoothly plastered with cement. The roof is usually constructed of the ordinary rafter and tie couples, set at 18-in. centres, and covered with 7 in. by ⅞ in. unchecked sarking, and slated with slates, which should all be of the *same* size, colour, thickness, and quality. The roof should always have rhones or eaves gutters to conduct the roof water by means of iron conductors to the drains. Instead of the usual style of couple roof, one may be formed with main or principal rafters set about 8 or 9 ft. apart, and measuring 9 in. by 2½ in. for the ordinary width of stable, with 5 in. by 2½ in. purlins. The sarking is then put vertically on the purlins, and should measure not less than 1¼ in. thick. This thickness is a great advantage, because the galvanized slate nails do not project through the sarking, and do not therefore rust owing to the foul air from the stable below.

If the ventilation to be put in the ridge is of the nature of a ventilator opening the whole length of stable, the top purlin on each side of the roof will be kept down a little from the apex, and the sarking will also be stopped short of the apex.

All the woodwork of the roof where seen in the stable should be clean dressed and then varnished, and the ironwork should be painted. This greatly increases the 'life' of the roof.

The roof should have a sufficient number of roof-lights. These roof-lights should all be made to raise or lower at will.

As regards the floor, the old system of causewaying with stones is now out of date. Cement floors will not stand the heavy tread and the kicking of farm horses. The back part or passage behind the horses may be laid with concrete 4½ in. thick, finished with 1½ in. thick of cement on top, all having a 6-in. layer of broken stones beneath. This cement floor might also be put below the manger for about 2 ft. wide. For the stall proper, where the horse stands, the ground should be excavated to a depth of about 18 in., and then have the two layers of stones and of concrete as above, without the 1½-in. cement layer. The layer of concrete is laid to the proper levels and then receives a coating of fine sand about ½ in. deep. Stone 'setts' of hard granite or whinstone, measuring 9 in. by 4 in. by 6 in. deep, should then be laid on this bed of sand. The joints must be fully grouted with cement mortar. The urine channel is laid in the same way, but with a slight hollow, about 2 in. to 3 in. deep, and not less than 12 in. wide.

The oldfashioned under-floor drains are now being dispensed with, and all urine is run to an outside drain wherever possible.

As to ventilating a stable, fresh-air inlets should be provided both in the front and in the back wall, formed with fireclay pipes cut to the exact thickness of the walls. In the wall at the horses' heads, these must be placed above the level of the horses' heads; but they may be placed at the floor level in the other wall, if it is desired to bring in fresh air where it should, theoretically, be admitted. To exhaust the vitiated air, ventilators must be placed in the ridge. No perfect ridge ventilator has yet been discovered. If servants could be relied on to attend to the ventilation in a regular manner, those ventilators that can be opened and shut as and when required are certainly to be preferred. But until we can secure that attention, then it seems necessary to have a ventilator that is always open and acting, and at the same time does not admit any draughts or snow or rain.

Travises may be made entirely of wood, viz,

wooden heelposts, foreposts, and planking; or the heelposts and the top and bottom ramp-rails may be of iron, with the planking only of wood.

The mangers are sometimes made with open spars for whole hay, with a fireclay feeding trough. Very often the manger is made close, like a box, in order to hold chaffed food, now so commonly given to horses. The height in either case from floor should be not less than 3 ft. to 3 ft. 3 in. Water pots should also be included. These are fed from a small cistern placed at the same level as the pots, with a ball-cock to regulate the flow of water.

Hay racks above the horses' heads should never be allowed. They destroy the eyesight of the horses by the dust and dirt dropping into their eyes. A hay loft above a stable is also to be very much deprecated. It interferes with the stable ventilation, and hay as a rule will not keep so well in a loft above a stable.

Doors to stables should always be wide and lofty—say 4 ft. 6 in. wide by 8 ft. high. The sliding door is preferable to the hinged door. The former works very easily if fitted up with 'Coburn' patent pulleys and iron sliding rails.

Besides the roof-lights, a stable should have as many side-wall windows as possible. A stable cannot be too well lighted. The lower part of the windows may be made to act as ventilators. A few recesses with shelves might also be put in a stable or in the harness room. The harness should not be hung in the stable, except perhaps at the midday meal, but should be placed in a properly constructed harness room, well aired, lighted, and heated by a fireplace. All harness fittings are best of wood and not of iron. The latter rusts and destroys the leather. Corn chests should be also placed in the harness room, out of reach of any horse that may happen to break loose. These chests can be obtained in great variety, of galvanized iron. A chest should be provided for every pair of horses, and have a lock and key attached to it. [C. W. S.]

Stack-building.—In the midland and southern counties of England, very wide stacks, either round or oblong, are usually built, because there the straw is generally more fully ripened and much drier at stacking time than in the north. Farther north, with a damper climate and softer straw, the size is limited by the condition of the crop at stacking time, and the stacks are usually made as large as they can be, short of causing heating.

Whether in the regular stackyard or in the field, stack bottoms should be slightly raised above the ordinary level of the ground by the earth from the intervening spaces being thrown on to them, after which the site of the stack should be further raised by placing on it old wood, branches of trees, old bricks, tiles, stones, &c. On the top of these, any old dry straw which may be available should be placed, so as to prevent as far as possible the damp from rising to the grain. Stack-stands made of iron or wood are also frequently employed (see art. STADDLES). Whether the stack is large or small, square, oblong, or round, it should always be begun by setting up a stook in the middle. Around this the sheaves should be built, keeping the heads well up at first, and allowing the sheaves to become flatter as the outside is reached. The sheaves near the centre, though placed in an almost upright position when building begins, gradually get crushed down as the weight above increases, until they ultimately become quite flat. In building the base, care should therefore be taken to keep the heads of each succeeding row of sheaves well above the bands of the preceding one. If this is done there will usually be sufficient straw below the head of each sheaf to prevent damage to the grain.

As soon as the bottom of the stack has been quite covered with sheaves, one or more rows should be put in the centre, according to the size of the stack. These are called 'hearting' sheaves, and are put in for two purposes: first, to keep up the centre of the stack; and second, to hold the stack together and prevent the outer row of sheaves from slipping out. Unless the centre of the stack is kept well up when being built, it will be lower than the outside when consolidated. When this happens, rain which falls on the ends of the outside row of sheaves runs right into the stack instead of off it, as it should do if the heads of the sheaves and the centre of the stack are kept sufficiently well filled up. After every outside row of sheaves has been built, the centre should be well filled up before another row is begun.

In building stacks in the southern counties of England three or four sheaves in depth are usually placed in position at one time, but in Scotland every course of one sheaf thick is completed and hearted before a second one is begun. In the north the sides of the stack project very little beyond the perpendicular, whereas in the south the eaves often project 1 or 2 ft. over the base. In the south the top or roof of the stack is usually made very much steeper than it is in the north, the reason being, that although the annual rainfall is less, more rain usually falls in a shorter time. By keeping the roof steep, the rain runs off very much quicker, whereas with the same thatch on a flat roof, a portion of it might run through and cause damage.

Where grain contains a considerable proportion of clover or ryegrass, or in districts that are late or sheltered, it is often very difficult to get the crop sufficiently dry to keep in even a small stack. In such circumstances three poles 10 to 12 ft. long may be set up in the centre of the stack in the shape of a triangle, and the sheaves built round about these. This in some places is called a bossing, and assists very materially in preventing overheating with grain in indifferent condition. [J. S.]

Stack Covers are used to protect stacks from rain whilst in the course of construction. The essential part of a cover is a big sheet, which may be used with or without pole supports. It is preferable, not only for the efficiency of the covering, but for the preservation of the cover, that it be carried on poles. For this purpose two tall poles or masts are set up, one at either end of the stack, previously to commencing building. The poles should be

A MODERN STABLE

firmly let into the ground, and must then be effectively stayed by guy ropes. A swinging beam is laid between the poles, and the cloth is suspended over it. The beam is secured at either end by ropes which pass over pulleys, which allow the beam and cloth to be raised and lowered at will. A rick cover should be rather larger than the stack it has to protect, and should be kept free from holes.

[W. J. M.]

Stacking Machinery. See HAYMAKING MACHINERY; ELEVATOR.

Stack-stands. See STACKYARDS and STADDLES.

Stackyard. — No modern homestead is complete without a suitable stackyard. To secure this, several conditions are essential. The site should be as convenient as possible to the farm buildings, although it need not be immediately adjacent to them. Wet, low-lying situations should be avoided: the wetness renders the surface easily cut up by cart or by wagon wheels, and perhaps impassable by portable threshing machines; while, if low-lying, the ventilation is apt to be insufficient for the completion of the drying of the crops after they have been stacked. Neither must the site chosen be too much exposed, otherwise the various operations of stack-building, thatching, threshing, &c., are likely to be frequently carried on under very unfavourable and exacting conditions. As a rule, the best exposure is to the north-west, north, or north-east wind; and this has the incidental advantage of providing some shelter to the farm buildings. The ground selected should be level, dry, and thoroughly underdrained. It is also necessary to have a good, firm, dry foundation, not so much for the stacks themselves as for the heavy traffic it will have to carry. The surface layers of soil should be removed to get down to the harder subsoil, a 2- to 3-ft. layer of large broken stones laid down, then a thin layer of smaller stones, and lastly a covering of gravel. Such a foundation not only ensures good drainage, but also a good firm surface even in wet weather. The best means of enclosing a stackyard is a substantial 4½- to 5-ft. stone-and-lime wall. A thorn hedge makes an effective fence, but if vermin happen to get a footing amongst its roots they are difficult to exterminate. A gate at least 12 ft. wide should be provided at the most convenient place for entrance and exit.

The size of the stackyard required depends mainly upon the rotation adopted and upon the size of stacks to be built. Generally a rectangular shape will be most convenient, with one of the narrower ends at right angles to the direction of the most prevalent wind.

The arrangement of the stacks within the yard will be conditioned by the method of threshing to be adopted. If threshing is to be done by the farmer's stationary machine, the rows of stacks can be placed contiguous to one another without any roadways between; while if a portable threshing machine is to be employed, the rows must be so arranged as to allow the threshing mill to be brought within easy reach for forking the sheaves from the stacks on to the mill; and in the latter case, space must always be reserved for the beginning of the straw stack at threshing. The stacks may be placed about 3 ft. apart, with roadways about 18 ft. wide, if such are required.

The foundation or 'bottom' of the stack is of great importance. Rick stands, wooden or iron, are now in common use, and these act partly as ventilators and partly as protection against vermin. Failing these, a 1-ft. layer of large stones proves an effective substitute, while for temporary foundations nothing suits better than a layer of large branches overlaid with some dry, second-rate straw or cuttings from hedgerows.

[J. W.]

Staddles, or **Steddles,** are raised frameworks on which corn is stacked. The object is to raise the stacks from the ground on pillars up which rats and mice cannot climb; and to provide all round ventilation to the stacks. They may have any shape, but are usually round or parallelograms. The pillars are made of iron or stone, and are provided with caps or heads somewhat mushroom-shaped, so that vermin climbing the pillars are unable to get into the stacks. The framework is sometimes of iron and sometimes of wood. [W. J. M.]

Stag Beetle.—This ferocious-looking insect, commonly found in woodlands, is described under LUCANIUM CERVUS.

Staggers.—The imperfect co-ordination of the voluntary muscles commonly spoken of as staggers in horses and in sheep has its origin in several causes. Staggering or trembling is one of the prominent symptoms of louping ill (which see), and from this well-recognized sign is in many districts better known as sheep staggers. The presence of hydatids or the intermediate form of tapeworm in the brain of sheep produces staggers, and a spinning round ending in a fall, and speedy restoration to consciousness (see GID). More frequent in sheep, it is nevertheless the cause of staggers in cattle and horses, hill ponies sharing the same conditions as sheep being most often the subjects. Diseases affecting the brain and spinal cord whereby undue pressure is exerted on a certain portion, or the normal pressure of the fluid is absent, result in a staggering gait or in varying degrees of paralysis; the inability to walk straight, or to turn short, or the swaying to one side being generally described as staggers. Disturbances of the cerebral functions due to suppressed sexual desire, to constipation and indigestion, to heart failure, diseased blood-vessels, tumours in the brain, injuries to the vertebræ causing pressure upon the spinal cord —any of these derangements may cause staggering; and it is important to ascertain the cause, and not attribute staggers to any one special malady which may be known to be prevalent in a district. The staggers caused by pressure of hydatids we have already described; but that more generally known as sheep staggers is distinguished from gid or sturdy by the early symptom of erecting the head, wild vacant staring of the eyes, and the jerky uncertain gait which in man would be attributed to alcoholism. The animal falls, is convulsed, para-

lysed, and dies; or lingers a few days and slowly recovers. This form of staggers is now believed to be transmitted through the agency of ticks; and on such land a dressing of half a ton of crushed rock salt to the acre has proved most effective in eradicating the disease from several districts. The coarse grass is cut in autumn and allowed to rot—a practice which appears to destroy nymphs and has manurial value for the following season. Staggering should always be regarded as a grave symptom in horses, as they may be attacked while in harness and become uncontrollable (see MEGRIMS), or the loss of control over himself may be due to brain tumour or other incurable lesions. Some horses stagger and fall over backwards when the head is elevated in order to administer a draught of medicine, and this has been traced to anchylosis of the neck bones and lesions to the spinal membranes. Plethoric horses, too full of blood and having insufficient exercise, appear to suffer from determination of blood to the head, and this causes staggering, just as the opposite condition of sudden withdrawal of blood in large quantity does. Heart failure or syncope and certain narcotic poisons induce staggering. See STOMACH STAGGERS. [H. L.]

Stall Feeding.—The primary reason for fattening cattle in stalls is to economize space and reduce the capital expenditure on farm buildings; but the advocates of stall feeding have several additional arguments in favour of the practice, the chief of which are, the possibility of feeding each animal according to its appetite and constitution, and the avoidance of bullying and horning which may occur in boxes and courts. On the other hand, stall feeding is wasteful of litter, produces inferior manure, and necessitates periodical grooming if irritation and consequent restlessness is to be avoided. Nevertheless, some of the best bred and most perfectly finished cattle are stall-fed. Some feeders have both courts and stalls, using the latter for the most forward animals, and as they are drafted out, filling the stalls with the best cattle from the courts. This is an excellent practice, as it admits of the use of a finishing ration suitable to each bullock. Store and young cattle are better in courts than in stalls. The stalls for full-grown cattle are of the same size as those for dairy cows, but it is not usual to provide a travis or partition as in cow stalls. In some districts the floor of the stall is a movable wooden grid laid on concrete, to save litter, and allow the free outflow of urine while maintaining a dry bed. [R. B. G.]

Stallion.—In the breeding of horses of all kinds, the selection of the stallion is of the utmost importance. Some breeders assert that the stallion transmits his characteristics to the offspring in a far greater degree than does the mare; but while this is undoubtedly the case in many instances, we must not overlook the fundamental principle that transmission of formation or temperament depends largely upon the prepotency of the sire or the dam. Given a stallion or mare endowed with this gift to a marked degree, it is easy to recognize the effect in the offspring, and the value of the parent for breeding as a result becomes much enhanced. It need hardly be remarked that the aim in breeding is to select a stallion particularly strong in some point wherein the mare is deficient, in expectation that he may transmit this special feature; but here again there can be no guarantee of success, as prepotency in the dam may defeat the object in view. In the choice of the stallion it is not judicious to be guided altogether by the conformation; we must investigate the pedigree and make sure that for several generations back the breeding is correct. Many stallions of mixed parentage are endowed with good looks, but prove unsatisfactory as sires because of the tendency such animals commonly possess of breeding back to previous ancestors, this being the natural result of the different strains of blood in their constitution; the purer the breeding of the sire the less chance there is of such reversion.

The chief characteristics of a stallion irrespective of breeding are size and substance; a bold, strong, masculine head and well-arched neck (those possessing effeminate, gelding-like heads and necks are frequently unreliable as breeders, and have difficulty in settling their mares); the chest should be deep and the body compact, with a short, straight, and powerful back; forearms and thighs muscular, plenty of flat bone below the knees and hocks, and the joints strong and well-developed. The pasterns should have sufficient length and slope, and the feet should be large and well-formed. His walk should be free and jaunty, and the stride long and level, while at both the walk and the trot the limbs should be kept well under the body and the hocks close together, any tendency to rotate the limbs or spread the hocks being objectionable.

The popular colours undoubtedly are brown, bay, and black, and at the present time the flash appearance of plenty of white about the limbs is admired, especially in the heavy breeds; still, it is questionable if this attribute is altogether to be commended on economic grounds.

Soundness of body, limbs, and constitution, and the possession of a well-balanced nervous system are most essential. Vice, nervousness, and liability to such objectionable diseases as stringhalt, roaring, shivering, &c., are in many instances markedly hereditary, and animals so affected should on no account be encouraged for stud purposes.

It would undoubtedly be of advantage were it made compulsory that no stallions should be allowed to beget progeny unless they themselves were free from hereditary disease. Under such conditions, it would only be a question of time until the standard of soundness of the various breeds would be raised to a much more satisfactory position than it at present unfortunately occupies.

An unsound mare is bad enough, but the results of such transmissible defects are confined to her limited number of progeny; whereas in the case of an unsound stallion serving a large number of mares every season, the perpetuation of hereditary defects assumes a much more serious aspect. [J. R. M'C.]

Standard.—As applied to trees and other plants this term indicates a length of upright stem supporting the head, as opposed to the dwarf or bush form. Full-standard fruit trees have about 6 ft. or 7 ft. of straight stem clear of branches, while half standards have 2 ft. to 4 ft. The advantage of the full-standard form is that the fruit is more out of the reach of stock, while in the case of half standards it is easier to gather. Roses are commonly grown as standards by budding the variety desired on to tall briers; and numerous other plants, such as chrysanthemums, pelargoniums, heliotrope, and rosemary, are grown in standard form for decorative effect. [W. W.]

Staphylinus is a genus of Rove-beetles, and a small larva, which is presumed to be the offspring of some one of the species (possibly a *Tachyporus*), has been detected injuring the wheat crops.

This larva is scarcely ¼ in. long; the head is furnished with strong jaws, feelers, and two little antennæ; it has six-jointed legs, terminating in claws; down the back and sides of the body are four rows of spines, being four on each segment; the tail has a fleshy foot, and two feelers, composed of four joints, which are useful in burrowing.

In October these larvæ attack the green wheat, causing the death of the plants by cutting round the stem with their strong jaws, about 1 in. underground; the object being to get at the white shoot, which they eat. At this early stage of the crop the empty husks of the grain remain attached to the roots, and into these the larvæ retreat when disturbed, making them their habitations, and possibly cells also, to undergo their transformation in. [J. C.] [F. V. T.]

Starch is one of the most important carbohydrates produced by plants, and constitutes the larger part of the dry matter of many crops. Starch is deposited in the form of granules with concentric layers, and the size and form of these granules differ in different plants, but the percentage composition and the chemical nature of starch are the same in all. Starch contains 44·4 per cent of carbon, 6·2 per cent of hydrogen, and 49·4 per cent of oxygen; thus having the hydrogen and oxygen in the same proportion as in water. Starch is not affected by cold water, but when heated in the presence of water the granules swell up and burst, forming a jelly or paste with the water. This gives a blue coloration with iodine in the cold water, which is a characteristic test for starch. Dry heating converts starch into dextrin, which is soluble in water but does not give the iodine reaction. Crude dextrin is largely used as an adhesive under the name of British gum. Under the influence of certain enzymes, such as diastase, which occur in germinating seeds and elsewhere in the plant, starch is successively converted into dextrin, malt sugar, and grape sugar. These form a series of closely-related compounds of diminishing complexity, starch and dextrin having the same percentage composition, whilst malt sugar and grape sugar contain an additional quantity of the elements of water. In the plant the various enzymes convert starch into dextrin, malt sugar, and grape sugar when the material is wanted for the nutrition of the cell or is to be transported from cell to cell. On the other hand, these simpler molecules are built up into starch as a storage product when the activities of the leaf in the manufacture of carbohydrates proceed more quickly than is needed to meet the immediate demands of the organism; hence in bright sunlight there is an abundant production of starch.

The value of starch as a food for animals depends on the ease with which it is converted into grape sugar in the alimentary tract. Ptyalin and other enzymes that are secreted as agents of digestion effect the hydrolysis of the starch as it passes along the alimentary canal, and the grape sugar is then absorbed and passes into the circulation. In this manner it is carried to all parts of the body, and serves to furnish the muscles and other organs with the needful supply of energy. The energy value of starch is equal to about 4·1 kilocalories per grm. In other words, the combustion of 1 lb. of starch, whether in the body of an animal or elsewhere, gives off heat sufficient to raise the temperature of 4100 lb. of water 1 deg. C. This heat, it need hardly be mentioned, has been derived from the sunshine absorbed by the green leaves in which the starch was produced.

Of the ordinary farm crops, potatoes may be mentioned as owing their value almost entirely to starch, the nitrogenous constituents being in very small proportion. The cooking of potatoes, which is so desirable when they are fed to cattle, pigs, or poultry, serves to burst the starch granules and thus render the material more amenable to the digestive processes. In the cereal grains the starch is of great importance also, though accompanied here by valuable proteins, and in the case of oats and maize by oil also. In malting it is the starch which is of value for the sugar it provides to undergo the alcoholic fermentation. So also if potatoes have become unfit for food their starch can be utilized after its conversion into sugar for the production of alcohol; and this can be obtained in an almost pure condition notwithstanding the condition of the raw material. [C. M. L.]

Starch Value, or **Starch Equivalent.**—The value of a foodstuff or ration for productive purposes (*e.g.* fattening, production of milk, &c.) may be very conveniently expressed in terms of the weight of some standard nutrient to which it is equivalent for the purpose in question. The most convenient standard nutrient to adopt for the purpose is *starch*, since in Kellner's classical investigations with fattening oxen we have a large number of direct comparisons of the values for fattening purposes of starch on the one hand, and of a variety of foodstuffs and pure preparations of albuminoids, oils, carbohydrates, and fibre on the other hand. The 'starch value' (German 'Stärkewert') of a certain quantity of a foodstuff or of a given ration is thus the weight of digestible starch to which it is equivalent for fattening or other productive purposes. For example, in one of Kellner's experiments 100 lb. of a linseed cake

containing 34·5 per cent digestible albuminoid, 8·4 per cent of digestible oil, and 26·1 per cent of digestible carbohydrates (including fibre) was found to give the same fattening increase as 77 lb. of starch; *i.e.* the 'starch value' of 100 lb. of this linseed cake was 77 lb. On the basis of his investigations Kellner has devised a method for the calculation of the starch values of foods from their percentage composition and digestibility. This method rests primarily upon the results obtained in experiments in which he compared the values for fattening purposes of pure albuminoids, oils, carbohydrates, and fibre, when added separately to a maintenance ration. Expressed in terms of starch as unity, these values were as follows:—

	Relative Starch Values.
Starch	= 1·00
Fibre (pulped)	= 1·02
Sugar	= 0·76
Albuminoid	= 0·94
Oil (in oil seeds and their products)...	= 2·41
Oil (in other seeds and their products)	= 2·12
Oil (in coarse fodders, chaff, and 'roots')	= 1·91

It will be seen that under the ideal conditions of these experiments, where each nutrient—even the fibre—was supplied in highly digestible form, the starch and fibre prove to be of equal value, the sugar decidedly inferior, and the albuminoid slightly inferior to the starch, whilst the relative value of the oil ranged from 1·9 in the case of the impure 'oil' of coarse fodders to 2·4 in the case of the pure oils, such as those of the oil-bearing seeds, nuts, &c. The low value of sugar as compared with starch is attributable to the wasteful activity of fermentative organisms in the digestive tract, these finding in the soluble sugar more easily acquired nourishment than in the more insoluble starch and fibre.

If now we may assume that the digestible albuminoids, &c., will exercise the same relative increase-producing powers when mixed together in the form of ordinary foodstuffs as they were found to possess when supplied separately, the starch value of a foodstuff (100 lb.) may be arrived at by means of the following expression:—

Starch value per 100 lb. = (digestible albuminoid per cent × 0·94) + (digestible oil per cent × 2·41 or 2·12 or 1·91) + digestible carbohydrates per cent + digestible fibre per cent.

Kellner found, however, that almost without exception the starch values thus calculated for different foodstuffs were higher than the values obtained by direct experiment with the foodstuffs. The discrepancies were only slight in the case of the highly digestible foodstuffs, but very great in the case of the highly indigestible and bulky foodstuffs. The following examples selected from Kellner's results are typical of the differences found between the calculated and actual values:—

	Decorticated Cotton-seed Meal.	Linseed-cake Meal.	Rye Grain	Bean Meal.	Wheat Bran.	Meadow Hay.	Oat Straw.	Wheat Straw.	Potatoes (dry matter).	Mangels (dry matter).
	lb.	lb	lb	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Starch value, Calculated ...	80·6	79·4	72·8	69·5	62·0	62·8	43·8	33·1	74·3	60·5
Starch value, Actual	79·4	77·4	68·1	65·7	47·9	43·9	26·6	9·7	72·9	52·7
Actual starch value expressed as percentage of calculated starch value ...	98	97	94	95	77	70	61	29	98	87

An explanation of the discrepancy between the calculated and observed values is not difficult to find. It must be borne in mind that the nutrients digested from any food have to provide not only for the productive purposes of the animal, but also for unproductive purposes, such as the labour involved in the mastication of the food and its digestion. The greater the demands upon the food for the latter purposes, the less will be the surplus of nutritive matter available for productive purposes; or, to use a term employed in a similar sense in connection with soils and manures, the lower must be the 'availability' for productive purposes of the digested matter. Now the labour involved in the mastication, &c., of a foodstuff will be largely determined by the amount and character of the crude fibre contained in it. Hence we may expect to find that the 'availability' of the digestible matter of different foodstuffs will steadily diminish as we pass from foodstuffs containing very little fibre to the foodstuffs rich in fibre of a hard character. The examples quoted above show very clearly that this is the case. Thus, whereas in the case of the easily masticated and digested oil-seed and grain foods the 'availability' of the digestible matter is 94 to 98 per cent, in the more fibrous wheat bran it is 77 per cent, in the still more fibrous hay it is 70 per cent, whilst in the case of the straws, most fibrous of all foods, it is 61 per cent for the relatively soft oat straw, and only 29 per cent for the hard wheat straw used in this experiment.

To return now to our expression for the calculation of starch values, in order to bring our results into accord with actual fact it is obviously necessary that the 'availability' of the digestible matter of the foodstuff to which the calculation refers shall be taken into account.

Kellner has rendered this possible by tabulating the percentage 'availabilities' (German 'Wertigkeit') of a large number of foodstuffs (see Kellner's Scientific Feeding of Animals, trans. by Goodwin, pp. 379–389).

A few examples will best illustrate the calculation of starch values by the method here outlined:—

Example I.—Linseed Cake containing 25 per cent digestible albuminoid, $9\frac{1}{2}$ per cent digestible 'oil', and 32 per cent digestible carbohydrate (+ fibre).

'Availability' (Kellner) = 97 per cent.

Starch value per 100 lb. $= [(25 \times 0{\cdot}94) + (9\frac{1}{2} \times 2{\cdot}4) + 32] \times \frac{97}{100} = 76$ lb.

Example II.—Oats containing 9 per cent digestible albuminoids, 5 per cent digestible 'oil', and 45 per cent digestible carbohydrate (+ fibre).

'Availability' (Kellner) = 95 per cent.

Starch value per 100 lb. $= [(9 \times 0{\cdot}94) + (5 \times 2{\cdot}1) + 45] \times \frac{95}{100} = 60{\cdot}8$ lb.

In the case of coarse fodders (hay and straw), chaff and green foods, Kellner recommends that instead of correcting the calculated starch values by means of the 'coefficients of availability' as in the above examples, the correction should be based upon the percentage of crude fibre (*total*, not merely digestible) in the food, in accordance with the following schedule:—

For each 1 per cent of crude fibre present, the uncorrected calculated starch value of hays, straws, and green foods containing 16 per cent crude fibre or more should be reduced by 0·58 (say 0·6).

Chaffs and green foods containing not more than 4 per cent crude fibre should be reduced by 0·29 (say 0·3).

In the case of green foods whose fibre content falls between the limits of 4 per cent and 16 per cent, a proportional correction should be made; *e.g.* for 6 per cent of crude fibre the correction per 1 per cent will be 0·34, for 8 per cent 0·38, for 10 per cent 0·43, for 12 per cent 0·48, and for 14 per cent 0·53 starch value.

The following examples will illustrate the application of this method:—

Example III.—Red Clover Hay containing $5\frac{1}{2}$ per cent digestible albuminoid, $1\frac{1}{2}$ per cent digestible 'oil', 38 per cent digestible carbohydrate (+ fibre), and 25 per cent *total* crude fibre.

Starch value per 100 lb. $= [(5\frac{1}{2} \times 0{\cdot}94) + (1\frac{1}{2} \times 1{\cdot}9) + 38] - (25 \times 0{\cdot}6) = 46 - 15 = 31$ lb.

Example IV.—Lucerne (green) containing 2 per cent digestible albuminoid, $\frac{1}{2}$ per cent digestible 'oil', 9 per cent digestible carbohydrate (+ fibre), and 7 per cent *total* crude fibre.

Starch value per 100 lb. $= [(2 \times 0{\cdot}94) + (\frac{1}{2} \times 1{\cdot}9) + 9] - (7 \times 0{\cdot}36) = 11{\cdot}8 - 2{\cdot}5 = 9{\cdot}3$ lb.

The experiments upon which the foregoing methods of calculating starch values are based were confined to the fattening of oxen, and hence, strictly speaking, the starch values thus arrived at apply only to this particular class of feeding. There is every reason to believe, however, so far as available information can give us any guidance, that, for the more concentrated foods at any rate, these starch values may be taken as fairly representing the relative values of the different foodstuffs for all 'productive' purposes, and all the common classes of farm stock, whether fattening oxen, sheep or pigs, working horses or milch cows. In all cases, *provided that the total ration contains a sufficiency of digestible albuminoids for the needs of the animal*, the relative 'productive' values of different foodstuffs or rations appear to correspond closely to their relative starch values as calculated by the methods explained above. There is some reason to believe that in the case of milk-producing animals a certain minimum amount of digestible *oil* must also be supplied in the ration before the different foodstuffs will 'produce' in proportion to their starch values. [C. C.]

Starling (*Sturnus vulgaris*).—This common gregarious bird is on the increase in Britain and is familiar to everyone. The black plumage

Starling

has a beautiful green or purple sheen, and is spotted with buff, especially in the female. The beak is long and curved. Starlings chiefly feed on snails, slugs, worms, and insects, catching many of the last on the wing. They also do good service by ridding sheep from various parasites. On the other hand, these birds undoubtedly attack grain, and fruits such as cherries, apples, and pears. In some districts their habits are undergoing change. The benefits conferred far outweigh the damage done to agriculture pure and simple, but fruit growers are justified in keeping the species in check, though even here a policy of extermination is not to be recommended. Breeding takes place in the early spring, and the untidy nest, made of the most varied materials, is built in all sorts of places. The four to seven eggs are pale-blue with a tinge of green. There are often two broods in the season. [J. R. A. D.]

Starters.—Starters have been employed for many years to hasten the souring of milk or cream in cheesemaking and buttermaking, but it is only recently that their nature and effects have been understood. Natural starters were obtained by allowing milk or cream to sour under natural conditions. Buttermilk and whey starters were also used.

In 1890 Dr. Storch conceived the idea of mak-

ing use of pure cultures of bacteria for starters in cream ripening, and the system has now been adopted extensively both in buttermaking and in cheesemaking in all the principal dairying countries. The first culture starters contained only one species of bacteria, but the commercial starters of to-day include more than one species. These bacterial cultures are prepared in the laboratory, and put on the market in the form of a dry powder, or as a liquid.

The principles of cream ripening by the use of culture starters are: first, the keeping of the milk as free from germs as is practicable, and the elimination, as far as possible, of the bacteria present in the milk by pasteurizing; second, the addition of a starter to give impetus to the desirable organisms, and to enable them to gain and maintain the ascendancy over other and less desirable species. Culture starters are also added to raw or unpasteurized cream, but the result cannot be so thoroughly relied upon. In buttermaking, and almost equally in cheesemaking, great improvement in quality has resulted from the general use of culture starters in the ripening processes.

A useful home-made starter may be prepared in the dairy as follows: Select a cow giving sound normal milk which sours without the production of gas or other taint. Have some of the milk drawn, with special care as to cleanliness, and keep this near 70° F. until partially curdled from acidity. Inoculate with some of this soured milk a fresh lot of pasteurized milk, and maintain it about 70° F. until this in turn is partially curdled. Repeat this treatment daily for several days. In this way a fairly pure starter may be prepared from ordinary milk, though culture starters prepared in the laboratory by bacteriological methods are to be preferred as being more reliable.

A commercial culture starter when received should be fresh, with the seal unbroken, and should be kept in a cool, dark place till the time of using. It should be pure to begin with, *i.e.* contain only the germ or germs specified, and these germs should be able to grow vigorously in milk at ordinary ripening temperatures, and produce lactic acid. It must be remembered that a starter is a living thing, and its vigour or vitality must be maintained. For this, great care in propagation is necessary. Heat some fresh, whole or separated milk to 180° F. for thirty minutes. Cool to 90° F. and inoculate with the culture preparation according to directions with the package. Keep in an enamelled vessel, covered lightly with a clean cheese cloth, at from 75° F. to 65° F. until partially curdled. The starter should at no time become too thoroughly curdled, but well soured to taste, and only partially curdled, with acidity not more than from ·74 to ·85 per cent as determined by the acidimeter. The vigour of a starter is impaired by strong acidity; lactic germs are checked and undesirable germs allowed to multiply in the starter. To prevent over-development at any time, dilute with some freshly pasteurised skim milk. Propagate the starter from day to day by adding a small quantity to a new lot of freshly pasteurised skim milk. The percentage of starter for inoculation and the temperature of setting vary according to requirements. A new starter requires to be 'built up' for a few days before using, and during this time its vitality will be increasing daily. But after a starter has been fully developed, good results will be obtained when the time allowed for ripening is from eighteen to twenty hours, the inoculation from 1 to 2 per cent, and the temperature of setting about 68° F.

The quantity of starter added to cream for buttermaking varies from 2½ to about 8 per cent, according to the temperature and time of ripening. The starter is introduced into the ripening vat before the cream. The top layer is skimmed off, the bottom portion also discarded, and the starter to be used strained free from curdy matter through a cream cloth. In cheddar cheesemaking, starter is employed at the rate of ¼ to ½ or even 1 per cent of the milk, and added to the evening's milk first thing in the morning. In the making of many of the soft varieties of cheese, a very few drops of starter may be used with good effects.

The germs in a starter are the seed and quality in the crop, and it is impossible to over-emphasize the importance that should be attached to the purity of the starter. A good starter when stirred up will be of a smooth consistency without the tendency to separate into curds and whey; free from gassiness, bitterness, and stringiness, and have a desirable sharp acid flavour and a pleasing aroma. Unless a starter is in a reasonably pure condition its use is likely to do much more harm than good; but a suitable starter intelligently used should result in an improved quality of butter or cheese. [W. ST.]

Statistics, Agricultural.—Probably the earliest agricultural statistics were returns of the numbers of live stock. Biblical history, at any rate, familiarizes us with enumerations of the flocks and herds at a very early period. So far as our own country is concerned, probably the first systematic attempt by the State to record statistics of agriculture was that made by William the Conqueror in the Domesday Inquest or Survey. This was extraordinarily detailed and precise for a large part of England, but of course it did not deal with Scotland and Wales. From time to time other partial attempts were made, mainly by the enterprise of individuals, as, for instance, Gregory King, Sir John Sinclair, and Arthur Young, to collect data of the agricultural resources of Great Britain, but it was not until 1866 that the present regular system of annual agricultural returns was instituted. Certain European countries had previously taken the lead by establishing periodical enquiries in connection with the census of the people or independently, both of the area under different crops and of the numbers of live stock.

Statistics of the agriculture of any country naturally divide themselves into three main groups, viz.: (1) the persons engaged, (2) the crops produced, and (3) the animals kept. These particulars may be collected in greater or less detail, but unless the main facts under these headings are obtained the position and progress of the agriculture of a country cannot be ascer-

tained. A record of the persons engaged in the industry is usually obtained by means of the census returns of the population, which are now as a rule collected decennially, and consequently the ordinary statistics of agriculture relate to the crops and live stock and do not include the personnel of the farms, except as regards the actual occupier. The basis of all crop returns is a return of the area planted with each crop. This is a definite and readily ascertainable fact. In certain countries statistics of the production of a particular crop are published when the acreage of that crop is not known, but although this may be achieved with some amount of plausibility it is difficult to feel confidence in the approximate accuracy of the results. If, however, the area is definitely known, the production from that area in each year can be calculated with some degree of assurance. The method of ascertaining the crop areas varies in different countries. Thus, in Great Britain it is obtained by means of a schedule filled up by the occupier of each holding. This is the most satisfactory method if it can be carried out. The occupier being assured that his return is regarded as confidential and that its contents are never divulged, but are employed solely for statistical purposes, has no motive for concealment or for false statement. In Ireland a similar but slightly different method is adopted, the returns being collected orally from the occupiers by the police. In France the returns are not made by the occupier, but by appointed persons in each commune who obtain by enquiry the particulars relating to each holding. Another method adopted in some countries is to obtain very detailed returns from the occupiers every ten years, in connection with the census of population, and year by year to estimate, after local enquiry, the increase or decrease of the acreage under each crop. It has been found, however, that this method is apt to lead to considerable errors, which are only discovered when the next decennial enquiry is made. The returns of animals on the farm are usually obtained at the same time, and in a similar manner, as those of the crops.

The question is sometimes raised whether the collection and publication by the Government of agricultural statistics is necessary or in fact desirable. It is indeed occasionally argued, by persons whose mental horizon is restricted, that official agricultural statistics are detrimental to the interests of farmers. It might almost be a sufficient answer to such persons that every civilized country now thinks it necessary and desirable to collect and publish statistics of their agriculture in the fullest possible detail; and that even in those countries where the ignorance and illiteracy of the farmers and peasants render the procedure most difficult, the State makes strenuous efforts to cope with the difficulty and to induce the occupiers of land to take an intelligent view of the matter. There is now hardly a considerable part of the civilized world—outside China and the Turkish Empire—for which agricultural statistics on a more or less complete scale are not available. The advantage of official returns to the farmer is best realized by imagining the position without them. Statements would be continually put forward, for example, of the increase or decrease of arable cultivation, the production of particular crops, or the number of cattle or sheep. They would be confidently made by irresponsible journalists, by imaginative politicians, or by interested traders, with the object of supporting some fad or of influencing the price at the markets. However erroneous such statements might be, and however convinced farmers might be of their error, there would be no means of contradicting them, and they would, if persistently reiterated, attain their object. The producer's best defence is the publication of the facts. Uncertainty as to the facts provides the speculator and the middleman with their most powerful weapon in dealing with the producer. It is the recognition of this fundamental truth that has led to the recent establishment of the International Agricultural Institute. Its primary object is to induce the Governments of every country to obtain the most accurate statistical information of their agricultural production, and to forward this to a common centre, so that eventually the world's production of all the important crops may be known with reasonable certainty. The task before it is beset with immense difficulty, and it may be long before its object is realized, but no one denies that if it can succeed it will prove of the utmost benefit to the cultivators of the soil in every country. [R. H. R.]

Steam Cultivation, as usually performed, does not differ materially from horse cultivation. The implements used are modified ploughs, cultivators, harrows, rollers, drills, &c., constructed to meet the requirements of practically unlimited power. Similarly, the tillage operations are limited to ploughing, cultivating, dragging, &c., so that, after the work is performed, there is little radical difference observable between the two classes of work. The chief points of difference between steam- and horse-cultivating implements are seen in the number of ploughs attached to the frame; in their turn-wrest type; in the absence of slades or soles; and in the attachment, in some cases, of subsoiling coulters to the plough frame. The 'cultivators' are generally five- or seven-tined, and are furnished with a turning apparatus. They are more efficient than horse cultivators, on account of their strength and weight, which, with the greater speed at which they are actuated, 'smashes' the ground completely and at the same time preserves the original surface on the top. Similarly, the width, strength, and rapidity of the steam-drags produce incomparably better work than can be accomplished by any horse-drawn drag or harrow.

The most successful steam tillage is therefore based upon an adaptation of the older implements to a new power, rather than in the adoption of novel appliances for dealing with the soil. It is true that 'diggers' and rotating tillers have been introduced—and, in fact, are still extant—in which attempts are made to pulverize the soil and produce a seedbed at one operation. But we may accept the types of modified tillage implements as fairly applicable to steam cultivation in its ordinary form.

Steam cultivation is most esteemed (1) on heavy clay land, where horse tillage is not only expensive, but limited by the time available for performing it. It is an enormous advantage to the occupier of such land to get it cultivated at seasonable times, and also to the required depth for its thorough pulverization. (2) On light soils, where wide implements can be used in order to get over a large area in one day. (3) On farms where special cultivations are necessary at certain times of the year, such as in continuous corn-growing, where it is important to prepare stubbles immediately after harvest, for autumn sowing.

On many farms steam is called in upon special occasions, either after harvest or in the spring, in order to forward the cleaning of land for fodder or for root crops; and this points to the advantage of contracting for the work at a specified price per acre. The question of cost is of vital importance, but is affected by that of efficiency. There are some light soils which are better tilled by horses, as steam is too rough, and sometimes too deep in its action, for them, and the treading of horses may also be distinctly beneficial to such soils. The cardinal points in favour of steam cultivation, such as unlimited depth, and the freeing of the land from the tread of horses, cease to be of importance on these soils, and the question of cost may be discussed without taking efficiency into account. Time also is a less important consideration in the case of land which can be ploughed whenever it is dry overhead, or harrowed without long delay, even after heavy rain.

In considering the relative costs of steam and horse cultivation there is reason for believing that the horse is very difficult to replace, so far as actual cost is concerned. The estimated cost of steam cultivation is liable to be placed too low, as sufficient allowance is often not made for deterioration in the value of tackle after it has been used for a few years.

As an adjunct to horse cultivation, steam is extremely valuable, and in many cases it may partially displace horses. It is, however, noteworthy that after a trial of at least sixty years, it has hitherto failed to oust the horse from its position as the most generally employed power on farms. It is no small advantage that horses can be used singly, or two, three, or four together; that they can travel over bad roads and soft land; and that they can be called upon or dispensed with at a moment's notice; that they require no repairs, except rest, and that they may be so managed as to be a source of actual profit.

The question of efficiency requires a few further words of explanation. Steam cultivation is said to be *so much better* than horse cultivation, that the question of cost ceases to be all-important. The efficiency of steam cultivation does not, however, appear to be in all cases greater than that of horse tillage. Horse ploughing is quite as good as steam ploughing, and, as to ordinary harrowing, it is one of its greatest recommendations on many soils that the horses tread the ground and render it firm after sowing. This is especially true of lea lands sown with wheat, or on the same land sown with oats, in the spring; and in fact in all cases where the land lies hollow, after the seed has been deposited. See also arts. LABOUR ON THE FARM; STEAM PLOUGH. [J. WR.]

Steam Diggers are large cultivators which break up the ground, not through tines being drawn through it as in ordinary steam or horse cultivating, but by breaking or stirring motions imparted to the forks or other attachments provided for the purpose. In almost all cases the digging parts have been placed at the rear of the traction engine, though in the early form of the Darby digger, which in 1880 was the first to demonstrate practically the possibility of digging, the engine was made to travel sideways, the digging forks being placed broadside to the engine, and presented a digging breadth of 21 ft. Although it attained some popularity it was not sufficient to command permanent success. The Procter digger was in reality a traction engine geared into a crank shaft which worked three forks at the rear, turning the ground as the engine travelled forward. Mr. Darby at the end of the 19th century brought out a decidedly novel digger, in which the digging action differed greatly from the 'kicker' motion imparted to diggers in use at that time. The effect in working was, that a rotary cutting and stirring action was set up as the engine moved forward. The land was undoubtedly well stirred, but there was no provision to effect thorough inversion, consequently it failed as a cleaner of the land, and failed commercially. The Cooper digger brought out in 1896 is the only one made in this country, and it has obtained sufficient popularity to make it successful. It is a thorough tiller and land cleaner, doing in one operation more actual cultivation than any cultivating machine yet brought out. The Procter digger crudely foreshadowed the Cooper digger, but the design of the latter throughout is markedly superior, and there are many features not present in the Procter. The attachment has a working width of 9 ft. 6 in. covered by a double row of forks, four in each row. The front row has prongs which are flat, chisel-shaped, and sharp, to enter hard ground; the back row has curved ones, to break up the ground turned, and to work out weeds. The forks have continuous motion in a vertical plane, and are driven at a speed which most thoroughly works the land. Despite the size of the machine all parts are under easy control, and work with great nicety.

[W. J. M.]

Steamed Bones, or degelatinized bones, are bones which have been treated under pressure with superheated steam to alter and render soluble a part of the nitrogenous matter which is removed as glue or gelatin. The bones are first cleaned and degreased and then steamed. The steaming removes from one-third to two-thirds of the organic matter of the degreased bones, and the remaining bone is much more brittle and easily ground than the original. The more thoroughly the bones are steamed the smaller the amount of organic matter left in them. As the organic matter of bones is

highly nitrogenous, and the glue or gelatin which is removed is a very nitrogenous substance, the steaming removes a large part of the nitrogen of the bone. On the other hand, the removal of the organic matter leaves the phosphate unaltered, and therefore steamed bones have a larger percentage of phosphate than the unsteamed bones. Clean raw bone contains about 4 per cent of nitrogen and 50 per cent of phosphate, whereas the steamed bone contains about from ¾ to 1½ per cent of nitrogen and from 60 to 70 per cent of phosphate (see BONE MANURES).

Steamed-bone flour consists of steamed or degelatinized bones ground to a fine powder. As steamed bones are brittle and easily ground, they are usually more finely ground than bone meals and bone dusts which are made from unsteamed bones. This causes steamed bone flour to form a very active and useful manure. In fact, numerous experiments have shown that weight for weight of phosphate it is generally more active than bone meal. At the market prices which have prevailed for bone manures for many years past, it is cheaper per ton, and also per unit of phosphate, than bone meal; it is therefore an economical bone manure for general use. It is frequently mixed with superphosphate, as it dries the superphosphate without reverting the soluble phosphate to the insoluble dicalcium-phosphate to any great extent. For analyses of steamed bone flours and further information, see the article on BONE MANURES. [J. H.]

Steam Engine.—Steam engines may be divided into two great classes—reciprocating

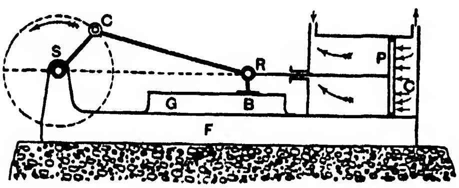


Fig. 1

engines and rotary engines. Many of the forms in which engines of the former class have been made have now become obsolete, the only form of this class of engine which is now in common use being the direct-acting form. In the same way there have been many forms of rotary engines, but of these only certain forms, known as steam turbines, are now made. The direct-acting, reciprocating steam engine, which, with the exception of turbines, is now used exclusively of all others, consists, in its simplest possible form, of the following essential parts: (*a*) a cylinder, fig. 1, containing a piston P, which is caused to reciprocate backwards and forwards from end to end of the cylinder by the pressure of steam acting upon it; and (*b*) a mechanism, consisting of a piston rod PR, a slide block B, and guides G, a connecting-rod CR, a crank, and a crank shaft S, working in bearings carried by the frame or bed plate F. The object of the mechanism is to communicate the reciprocating motion of the piston to, and convert it into the rotatory motion of the crank shaft. The cylinder of an ordinary steam engine is usually provided with two openings in the barrel, one at each end, called steam ports, through which the steam, controlled by a slide valve, usually, passes alternately to and from the cylinder. A longitudinal section of the cylinder of a direct-acting steam engine, showing the steam ports SP_1 and SP_2, the exhaust

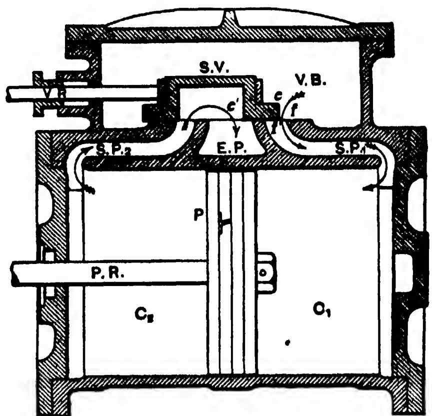


Fig. 2

port EP, and the slide valve SV, is given in fig. 2. The slide valve is driven from an eccentric on the crank shaft. This eccentric is merely a form of crank, the rotatory motion of which, by means of an eccentric rod and valve rod VR, is communicated to the slide valve, causing the latter to reciprocate backwards and forwards much in the same way as does the piston, but on a smaller scale. In fig. 2 the valve is shown admitting *live* steam from the valve box VB to the end C_1 of the cylinder through the steam

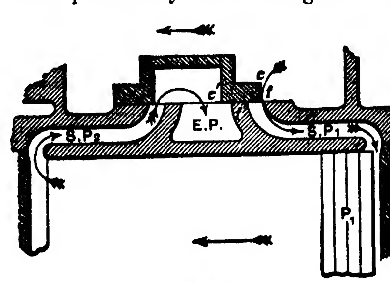


Fig. 3

port SP_1, and allowing steam to exhaust from the other end, C_2, of the cylinder, through the ports SP_2 and EP, into the atmosphere or condenser. As the slide valve reciprocates backwards and forwards it alternately admits live or boiler steam to, and allows the escape of exhaust steam from, each end of the cylinder as follows: When the piston P, fig. 2, is just, or almost, on the point of commencing its outward stroke, as shown at P, fig. 3, the edge *e* of the valve—which will then be moving towards the left—will be opposite

the outer edge f of the port SP_1, as shown in fig. 3, and admission of steam to the right-hand end of the cylinder will commence. After a short interval the valve, having arrived at its extreme position on the left, will begin to return, and, when the edge e of the valve comes opposite to

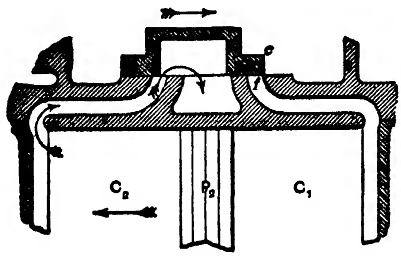


Fig. 4

the outer edge, f, of the steam-port again, admission of steam will be cut off and expansion will commence; the relative positions of piston and valve now being as shown in fig. 4. Then, the valve still moving towards the right, when the inner edge e' of the valve comes opposite to the

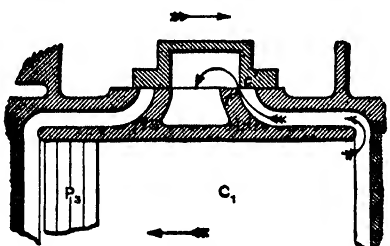


Fig. 5

inner edge f' of the right-hand steam-port, as shown in fig. 5, the steam will be released from the end C_1 of the cylinder, and will escape into the atmosphere, or condenser, through the exhaust port. After the valve has reached its extreme position on the right it begins to move

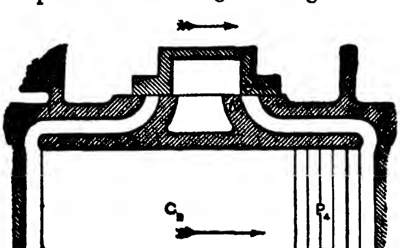


Fig. 6

towards the left, and when e' comes opposite to f' again, the piston will be approaching the end of its inward stroke, as shown at P_4, fig. 6, the escape of steam from the cylinder will be stopped, and compression will commence.

The variations of pressure which take place on the back of the piston are indicated in the indicator diagram shown in fig. 7, where AC′ represents the stroke of the piston. During admission or while the piston is moving from A to B, the pressure will be constant, and almost equal to the boiler pressure, as represented by the line ab. At B cut-off takes place, and as the piston advances to C the steam expands and the pressure falls, as indicated by the line bc. When the piston arrives at C release takes place, the pressure rapidly falls still further to cc''—the back pressure—and then remains constant, as indicated by $c''d$, until the piston has returned to D. At this point compression commences and

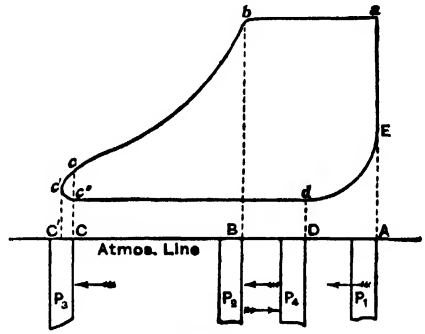


Fig. 7

the pressure begins to rise again, gradually at first, to E, and then suddenly, to a, as admission takes place.

In a similar way the outer and inner edges on the left-hand side of the valve control the admission, cut-off, release, and compression with respect to the left-hand end of the cylinder, the indicator diagram for which will be somewhat of the form shown in fig. 8. These diagrams are automatically drawn on paper by an instrument called an 'indicator'.

In the case of double-acting engines, indicator diagrams are taken from both ends of the engine

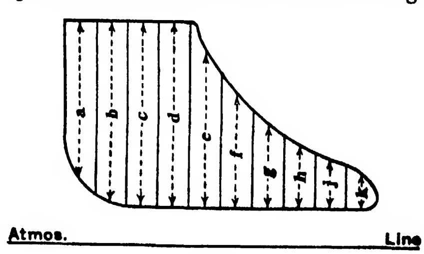


Fig. 8

cylinder, or cylinders, and from these the 'indicated horse power' of the engine is determined.

A small portion, from about 5 per cent to 15 per cent, of the i.h.p. of an engine is expended in overcoming frictional resistances in the engine itself, and the remainder, which is available for doing useful work, is called the 'effective' or 'brake horse power' of the engine.

A simple direct-acting steam engine is illustrated in fig. 9. In addition to the essential parts already referred to, such engines are usually provided with: (1) a heavy flywheel to

render the motion of the shaft throughout each revolution as uniform as possible; (2) a governor, to keep the speed within fixed narrow limits under a varying load, which it does, in

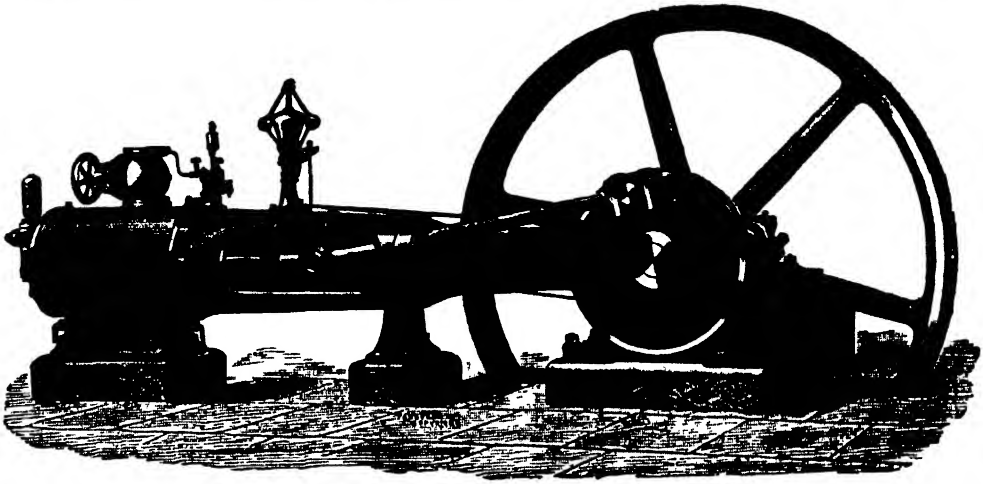


Fig. 9—Horizontal Non-condensing "Girder" Type Engine

small engines, by throttling the entering steam; (3) a stop valve, for admitting boiler steam to and shutting it off from the steam box, &c.

Reciprocating steam engines are classified as: (*a*) Single-acting, or double-acting, according as the steam acts upon one side of the piston only, or upon both sides; (*b*) non-condensing, or condensing, according as the steam on leaving the cylinder is passed into the atmosphere, or into a condenser; (*c*) stationary, locomotive, or marine, according to the kind of work it performs; (*d*) simple, or compound.

As the steam enters the cylinder of an engine it acts upon the piston and drives it forward. Before the piston reaches the end of its stroke, however, the supply of steam is usually cut off and the stroke completed by the expansive action of the steam. The steam may now be led into the atmosphere, or into a condenser, or into a second cylinder where it is made to do work in the same way as it did in the first. When steam does work in one cylinder only, the engine is called a 'simple' engine; if it does work in two cylinders in succession it is a 'compound' or double-expansion engine; if in three cylinders it is a triple-expansion engine; and if the same steam undergoes four separate expansions in four (or more) cylinders it is called a quadruple-expansion engine. The number of expansions which gives most economical results depends largely upon the initial pressure of the steam supplied to the engine. Thus for initial pressures up to about 85 or 90 lb. per sq. in. by gauge, simple engines are generally used. For pressures between 85 lb. and 150 lb. per sq. in.,

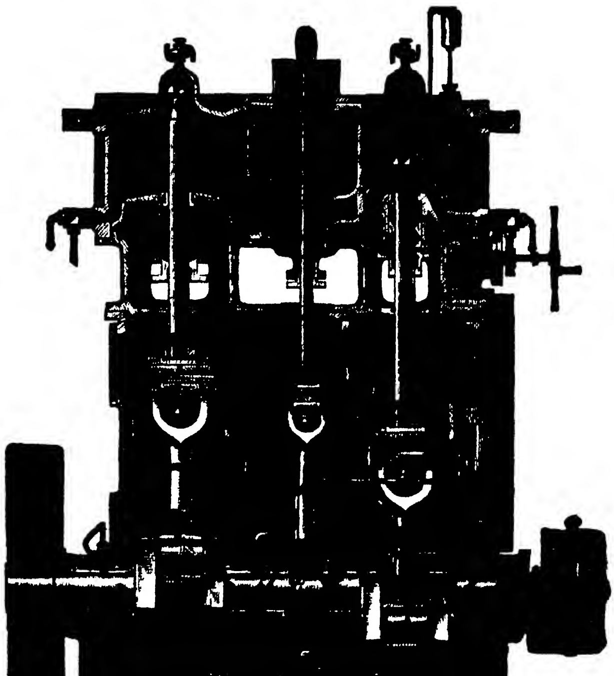


Fig. 10.—Front Section of Belliss Compound Engine

two-cylinder compound engines are usual. And for engines using steam at pressures between 150 lb. and 220 lb., triple expansion is chiefly adopted, though quadruple expansion is not uncommon when the initial pressure of the steam exceeds 200 lb. per sq. in.

The classes of engines chiefly used upon or about the farm are simple, double-acting, non-condensing, and either stationary or locomotive traction. Two-cylinder compound engines of both the condensing and non-condensing types are, however, sometimes used. A quick-revolution, two-cylinder compound engine, particularly well adapted for driving dynamos, is illustrated in fig. 10. In this engine the steam, after acting upon the piston in the right-hand cylinder—called the high-pressure cylinder—passes into the larger cylinder on the left—the low-pressure cylinder—and the admission, release, &c., of the steam for both cylinders is controlled by a slide valve having the form of a piston, called a piston valve, which is placed between the two cylinders, as shown.

Of steam turbines there are several types, the simplest being the De Laval steam turbine, shown in fig. 11. This turbine, which is often used for driving cream separators, &c., in dairy farms, works very much like a water-jet wheel—that is, jets of steam impinge on vanes, the resulting impact driving the wheel round.

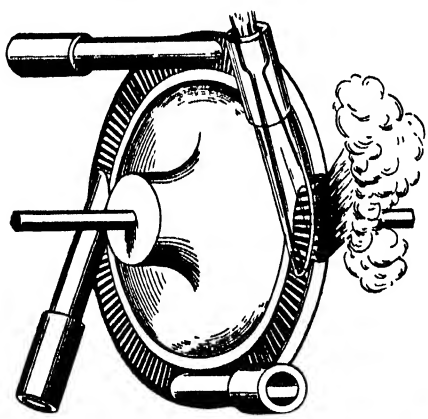
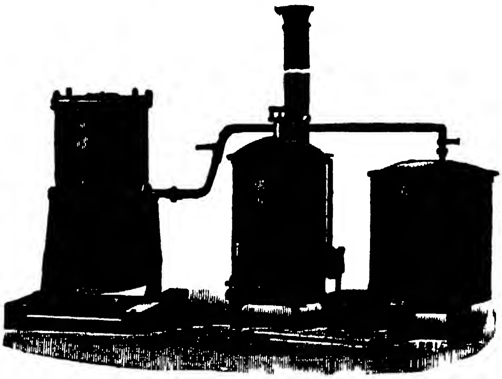


Fig. 11.—De Laval Steam-turbine Wheel

In the illustration two pairs of nozzles are shown, the nozzles in each pair being parallel, but on opposite sides of the shaft, and pointing in opposite directions. [H. B.]

Steaming Apparatus.—The apparatus for steaming to suit all classes of food, including corn, must be designed for loose fodder, and heavier substances such as roots, corn, &c. Messrs. Barford & Perkins have long been identified with this class of food-preparing through their dual-purpose plant, where a portable boiler supplies suitable steamers through steam pipes leading to each. If a boiler exists on the farm, the special boiler need not be provided. A cheaper form, however, is made in which the whole heating and steaming apparatus is combined, and this answers well. When large quantities of material have to be used, closely tongued wooden bins or vats are desirable. Ordinarily these are made to hold 200 bus.

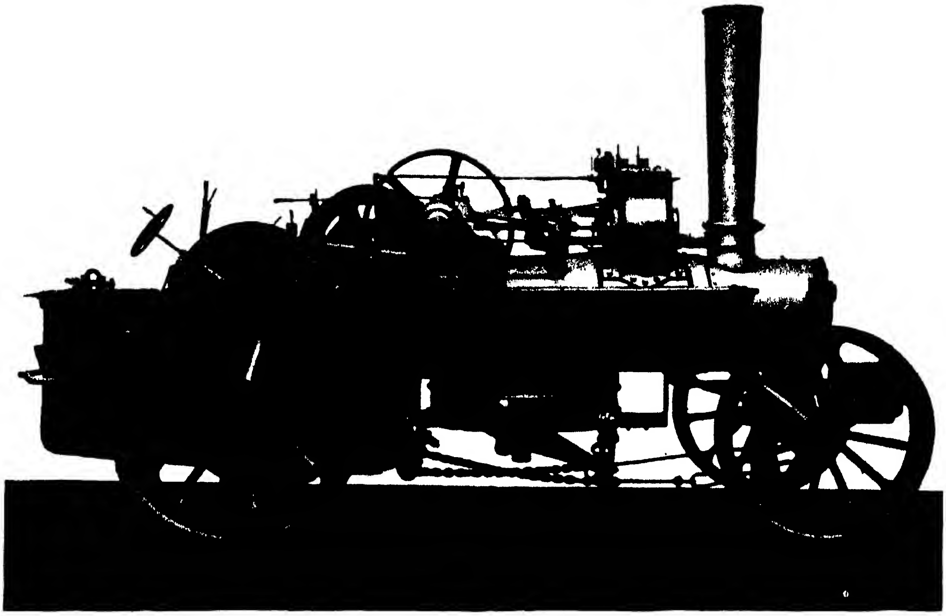


Barford & Perkins's Steam Food-preparing Apparatus

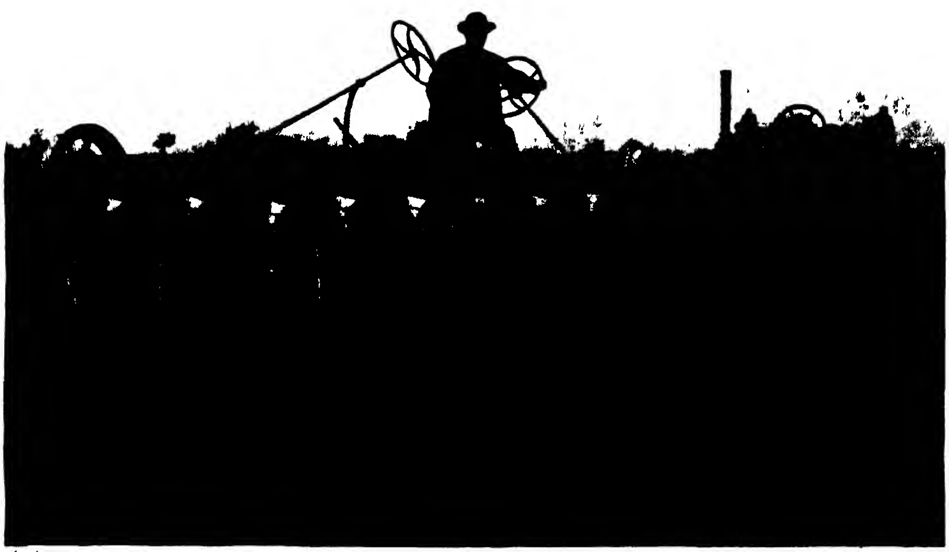
upwards; and as the best effects of steaming are obtained after the material has been treated for three days, it is a decided advantage to use two bins. The steam is led into the bins by pipes laid underneath, with perforations so that the steam may attack the whole of the bottom layer, and then permeate through the mass. [W. J. M.]

Steaming of Food.—The effectiveness of many foodstuffs can be appreciably increased by boiling with water, or still better, by steaming. In some cases (*e.g.* potatoes intended for pigs) this treatment is commonly recognized to be absolutely necessary, whilst it is the only practicable method of rendering foodstuffs that have become mouldy or infested with animal parasites, serviceable as food. In the latter case the steaming will not only destroy the organisms, but will also remove the unpleasant-smelling products of their action. The benefits derived from steaming do not arise from any increase of digestibility—the tendency indeed being rather in the opposite direction—but rather from improved palatability, and, in the case of hard foods, the softening of the fibre and the consequent lower drain upon the digested nutrients to provide for the labour of mastication. Little gain is therefore to be expected from the steaming of sound foods that are readily consumed in the ordinary condition, unless, as in the case above-mentioned of potatoes, there be risks involved in the consumption of the raw food (see Potato, Products of). A further exception may also be made in the case of animals fed on scanty rations and exposed to low temperatures. The requirements of the body for heat form in such cases a serious drain upon the food supply, and the direct supply of heat in the form of steamed food may hence result in an appreciable economy of food.

Boiled and steamed foods are better adapted for fattening animals (notably pigs) or milch cows than for animals of more active disposition, such as young stock. They are least suited for



STANDARD TYPE OF COMPOUND PLOUGHING ENGINE FOR USE WITH DOUBLE-ENGINE SYSTEM



(197)

TURN-ROUND PLOUGH AT WORK (DOUBLE-ENGINE SYSTEM)

[Engineers: John Fowler & Co. (Leeds), Limited]

horses and sheep. Care must always be taken to avoid the systematic use of such quantities of steamed or boiled food as involve the consumption of excessive amounts of water, since this may lead to a weakening of the digestive organs and of the constitution generally. The same caution applies also to the temperature of the food when supplied to the animals. This should not appreciably exceed blood-heat. [C. C.]

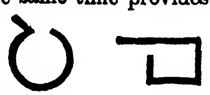
Steam Plough and Cultivator.—Steam ploughs are less used now than they were thirty years ago. Injudicious use, too deep work, the heaviness of the engines, the initial cost, the need of so much labour to work a set and keep it supplied with water, among other things, prevented their general use. Steam cultivating, however, being more expeditious, less injurious to the land by reason of undesirable subsoils not being brought to the surface, &c., has attained to much more popularity, and under many conditions can be carried out with great advantage. Still, there seems little probability of any extension—in fact, a much greater one of diminution—of the use of the steam cultivator, at any rate in the form in which it has hitherto been made; and the coming of the oil-driven automobile tractor, with its wide application to other work in addition to cultivation, precludes likelihood of the steam plough being retained for any great length of time. Ploughing and cultivating by steam has been done by single-engine and double-engine sets, but in recent years the use of single-engine sets has practically died out. The single-engine set had the advantages that ploughing could be done without taking the heavy engine into the field, and smaller initial cost; but the setting down of snatch blocks, anchors, porters, paying out of cable, &c., involved much time, and the double sets proved more profitable to those who let out sets on hire. The double sets are simple to set to work, as all that is necessary is to place an engine at either side of the field and alternately haul the plough or cultivator backwards and forwards, for which purpose each engine is fitted with a rope windlass. Cultivators are made in many sizes to adapt them to the work required to be done; and, apart from stirring implements to break up the land, suitable combined implements for preparing a seed-bed and sowing it are also made, and are profitably employed on large tracts of land in countries possessing a drier climate than Great Britain; and it is in these countries where this form of cultivation is likely to be continued after steam cultivation is even less practised than it now is in Great Britain. The use of the steam plough for exceptionally deep ploughing is also likely to be continued in some countries where special conditions prevail. [W. J. M.]

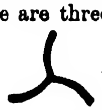
Steelbow.—Formerly it was a common practice in Scotland for the landlord to provide the tenant with the stock, farm implements, &c., necessary for the working of the farm, these goods being known as 'steelbow'. The custom has, however, completely died out, leaving only one trace in the stipulation, common in leases, that the tenant shall leave on the lands at his waygoing the unused straw and manure. The contract known as the bowing of cows (which see) in some respects resembles the lease of steelbow goods. [D. B.]

Steelyard.—The steelyard is a weighing machine in which the principles of the lever are employed. The hanging hook by which the instrument is suspended is borne on a knife edge forming a fulcrum; the material to be weighed is attached to hooks carried on the short arm of the lever; and the long arm is graduated to indicate the weight. A compensating weight in ratio is carried on a knife edge to bed into the notches, and is moved along until the indicator about the fulcrum is vertical. A great advantage of the steelyard is its portability, and suitability to weigh bulky materials such as hay, straw, &c. [W. J. M.]

Steeplechasing.—At first sight the name which has been given to this sport appears somewhat incongruous and even ludicrous. Nevertheless the word is truly descriptive of the origin of the sport. In the old days the country gentry used sometimes to wish to test the qualities of their hunters, and to compete against each other, when no opportunity of chasing a live animal showed itself. A steeple is a conspicuous object on any landscape. The riders used, therefore, to collect some miles away from a steeple, in the neighbourhood of which winning-posts had been set up, and then raced across country with one eye on the tower and the other on the nature of the ground—in short, they chased the steeple. It is from this primitive pastime that the elaborate sport of the present day has evolved. The first recorded steeplechase took place in Ireland in 1752, and was over 4½ miles of country, 'from the church of Buttevant to the spire of St. Leger church'. As time went by the courses became more and more artificial, and it became the custom for crowds of spectators to congregate to see the fun. The character of the 'mounts' employed has also radically altered. Hunters have not the speed to make any show in a modern steeplechase. The real 'chaser' is, in fact, quite a modern product, and is a racehorse which can jump, not a hunter with an exceptional turn of speed. When an animal fails for some reason or other at flat-racing, his owner will frequently try him at steeplechasing, and often with remarkably successful results. It is a strange thing that many horses who do not possess the ability to 'stay' five furlongs on the flat, are yet able to distinguish themselves at four miles when they are put to steeplechasing. This becomes the more remarkable when it is remembered that the speed in the latter case is only slightly slower than in the former. The Grand National is run only seven or eight seconds slower per mile than the Derby, although the former race is three times as long as the latter and much heavier weights are carried by the horses in the Grand National. The explanation of this probably is that the very top speed of an animal, as compared with a very slight slackening, requires the expenditure of an amount of energy out of all proportion to the gain in pace. At all events, this same large gain in endurance through a very slight slackening of speed is exhibited by men as well as by horses. The

Grand National was started in 1839. It was at first a sweepstake of 20 sovereigns each, 100 added; 12 st. each; gentlemen riders; 4 miles across country. The National Hunt Steeplechase was started in 1860. There are very few horses who take readily to jumping, and the training of a 'chaser' ought to be very gradual. Good shoulders are an essential characteristic, as without them a horse is apt to pitch on landing. [H. S. R. E.]

Stells are artificial shelters built on the hills for the protection of the sheep in time of storm. They are generally of dry stone walls; but in cases where building stones are scarce, 12 to 18 in. of turf may be put on the top of stones built to the height of 3½ to 4 ft. The configuration of the hill determines the best place to erect a stell. Stells are either for the protection of sheep in time of snowfall, or snowdrift, or to act as wind-breaks. The former class of stells are generally erected at or near some good feeding ground, where the sheep can easily obtain a bite without going far from their shelter. The latter class, or black-weather stells, are for the most part put on exposed or prominent parts of the hill, and their effect can be appreciated for a long distance. Stells are built of various shapes and sizes. The most common type is the circular stell, which does not fill with drifting snow so easily as a square building would; but whether the stell is round or square it is provided with a wing which helps the shepherd to guide the sheep to the entrance, and at the same time provides additional shelter, thus:— 

At stells there is usually placed a small stack of hay, which is fed to the sheep in time of heavy snow. Black-weather stells are of various shapes —the most common being T or +, but sometimes there are three legs like an Isle of Man halfpenny . At almost every stell the shepherd has a small enclosure in which he can shut a ewe with a lamb, and this often saves him driving an odd sheep a long way during the lambing season. [W. B.]

Stephens, Henry (1795–1874), agricultural writer, was born at Keerpoy, in Bengal. He was educated in Scotland, first at a school in Dundee, and then at Edinburgh university. Leaving the university, he had a thorough training in practical farming under one of the best farmers in Berwickshire, and then went on an agricultural tour to the Continent. On returning, he came into possession of a farm at Balmadies, Forfarshire, which he managed with conspicuous success, introducing many improved methods both in land cultivation and in the feeding of cattle and sheep. He afterwards retired to Bonnington, near Edinburgh, where he died in 1874. It was during this last period of his life that he published his agricultural works. Of these the Book of the Farm is the best known, and is, in its subsequent and revised editions, still proving a lasting memorial of the fame of its originator. His other works are: A Manual of Practical Draining, The Yester Deep Land Culture, and A Catechism of Practical Agriculture. In conjunction with Robert Scott Burn, James Slight, and Dr. Wm. Sellar, he published books and pamphlets on such subjects as Implements and Machines, Farm Buildings, Physiology and Non-nitrogenized Foods, &c. He was editor of the Quarterly Journal of Agriculture, and up till 1852 he edited the Transactions of the Highland and Agricultural Society of Scotland. He was also a member of several foreign agricultural societies, and prior to his death received a gold medal from the Emperor of Russia. [A. M.]

Sterility.—This subject is dealt with under the heading Barrenness, but it may be convenient in the present article to refer to certain causes of sterility not treated of elsewhere. Apart from the more special forms of sterility due to various kinds of disease, this condition may result from lack of sufficient nourishment (or of the right kind of nourishment) for the developing germ cells in the essential organs of reproduction. Even under normal conditions many of the ova in the ovary, instead of becoming mature, undergo degeneration *in situ*, and this process may take place at all stages of development. It is most liable to occur in underfed animals, or in animals which for one reason or another are unsuited to their environment. When it is very frequent it leads to a reduction in the fertility, and sometimes to complete barrenness (at least temporarily). This result is due to the great scarcity or even absence of ripe ova available for fertilization by the male. The effect of 'flushing' sheep (or of bringing them into a good thriving condition) at the approach of tupping time is to increase the number of ripe ova at this season, and so to improve the fertility (see art. Fecundity). The additional feeding when not overdone has the effect of hastening the development of the ova in the ovary, and preventing them from lapsing into the degenerate condition.

Infertility may also result from excessive overfeeding. In this case the animals come 'on heat' irregularly and sometimes not at all. This is due to a disturbance of the ovarian metabolism, since it has been shown that 'heat' is brought about through the functional activity of the ovaries, and probably by an internal secretion elaborated in these organs. (See Œstrus.) In cows and heifers which have been fattened it is common to find deposited in the ovaries a bright-orange or yellow pigment, known as lipochrome, and it is interesting to note that the presence of this substance is often associated with degeneration of ova.

Barrenness due to excessive fat on the one hand, or insufficiency of nourishment on the other, may usually be remedied by a return to normal conditions of feeding, since the degenerative processes do not usually extend to the more immature ova (at any rate not to all of them), and certain of these are usually able in course of time to become fully developed and so ready for fertilization.

Certain veterinarians now state that the drug

Yohimbine is a useful remedy for certain conditions of sterility. However this may be, there can be no doubt that it has a specific action upon the reproductive system, both in the male and in the female, since it causes a marked congestion of the reproductive organs, and more particularly the uterus and female generative tract. It is extremely probable, therefore, that this drug tends to promote the ripening of ova and to arrest degeneration by providing the ovaries with a rich supply of blood and consequently of nourishment. It is usual to administer Yohimbine by the mouth in the form of tabloids, ·005 grain given twice daily for a fortnight being sufficient to cause marked congestion of the external generative organs in a bitch terrier.

Sterility, either partial or complete, may apparently result from long-continued inbreeding, though more evidence is wanted relating to this question. It is an ascertained fact, however, that many inbred animals (*e.g.* Dorset Horn sheep) that are sterile when crossed with rams of their own breed, are nevertheless fertile when crossed with individuals belonging to another breed (*e.g.* Dorset Horn ewes when crossed with Hampshire Down rams). It would appear as if the germ cells (ova and spermatozoa) in such inbred animals may in some cases be possessed of insufficient vitality to admit of their uniting with one another in fertilization, or of their undergoing subsequent development if they do so unite. Close confinement or change of environment may also lead to infertility, for the reproductive organs are peculiarly susceptible to external influences. In such cases the sterility is often only temporary, the organs recovering themselves in a short space of time by responding to the new conditions. On the other hand, change of surroundings is sometimes a remedy for the deteriorating effects of inbreeding. This is said to be the case with Thoroughbred horses imported to Australia, the change of climate having a rejuvenating influence. [F. H. A. M.]

Sterilization means simply the act of making sterile any substance which contains microbic life, or, in short, the destruction of microbic life. It has another meaning, namely, to render incapable of propagating life. The methods by which sterilization is effected in organic or inorganic substances vary with relation to the substance to be sterilized or to be rendered sterile. The agencies employed are: (*a*) dry heat, (*b*) moist heat or steam, and (*c*) chemical germicides.

Sterilization is one of the most important processes to be carried out in the bacteriological laboratory, because without sterile material sure results would be impossible. Laboratory methods for this end may be carried out on the large scale.

(*a*) *By Dry Heat.*—Platinum needles, points of forceps, and other metallic instruments are sterilized by heating to dull redness in the Bunsen flame; cover-glasses, microscope slides, and all empty glass vessels, by exposure to like heat, but in less degree. All glass apparatus ought to be placed in the oven when it is cold, and the temperature gradually raised to 170° F., and maintained at that point for at least one hour, the apparatus being left in the oven until the oven is cool.

(*b*) *By Moist Heat.*—Steel instruments, the temper of which would be injured or destroyed by exposure to live flame, are best sterilized by being boiled in water for at least twenty minutes after the water has commenced to boil. Five minutes' boiling will destroy most microbes, but may fail to kill spores; but if the boiling be maintained for one hour, all microbes and spores are completely destroyed. Steam at 100° C., or 212° F., sterilizes as effectively as boiling water. Most media in which microbes are cultivated, other than those containing gelatin, are so sterilized, the time allowed being one and a half hour. Gelatin media are best sterilized by Tyndall's intermittent method—by exposure to steam at 100° C. for fifteen minutes at one time on each of three successive days. This process is carried out in a Koch or other sterilizer, the process being completed at the end of one and a half hour. Steam generated at 120° C., under a pressure of two atmospheres, kills all micro-organic life after an exposure of fifteen minutes. This operation is carried out in the autoclave, which consists of a strong steel cylinder, the cover of which is clamped by binding screws to the body when in operation. The required temperature of the steam to be generated is determined by the pressure, which is obtained by weighting the valve, the pressure being indicated by a manometer or pressure gauge. The heating is supplied by gas or oil or spirit. For materials other than those composed of gelatin, an exposure at 120° C. for two hours is given, and for gelatin media the temperature should never be raised above 105° C., and the time of exposure should not exceed three minutes, else the 'setting' property of the gelatin will be impaired or destroyed.

(*c*) *By Chemical Germicides.*—These are utilized for preparing the skin of an animal about to be inoculated or dissected, and the hands of the operator, and for destroying cultures and preparations of microbes when no longer required.

Sterilization is also the objective point aimed at in disinfection (see DISINFECTANTS). Heat is a valuable bactericide when applied as dry hot air, moist heated air, boiling water, or steam. The only practicable mode of disinfecting certain fabrics or articles containing feathers, hair, &c., such as cushions and mattresses, is by steam under pressure. Dry heated air, even under pressure, has been found by experiment to be inefficient, unless at such high temperatures as are bound to scorch. To kill organisms and spores, a temperature between 212° and 220° F. is necessary, but it has been found impossible by dry heated air to obtain this temperature in the interior of a mattress even after long exposures. Steam under pressure, therefore, is the most effective method of sterilizing infective materials. For this purpose disinfecting apparatus, called disinfectors, are employed. A good disinfecting apparatus should possess the following essential qualifications: (1) its mechanism should permit the steam under pressure to penetrate and permeate thoroughly the articles to be disinfected; (2) the temperature of the steam

should be between 221° F. and 270° F.; (3) the apparatus should be so provided with valves that, alternately, hot dry air and moist steam within the foregoing range of temperature may be passed into the chamber containing the articles to be disinfected or sterilized.

Sterilization is produced in the preparation of 'canned' foods and bottled goods. In the process of canning meat of various kinds, fish, shellfish, and others, two objects are desired: (1) the effective cooking of the contents of the cans, and, thereby, the sterilization of the same; and (2) the preservation of the contents from the intrusion of micro-organic life. The method adopted is to boil or otherwise cook the food to be placed in the cans, thereafter to place the food therein, and then to solder the lid on the can, leaving a pinhole opening in the top of the lid. The cans are now nearly completely immersed in a boiling fluid until steam freely issues from the interior of the can, at which stage a drop of solder is allowed to fall upon the pinhole opening, thus closing it and sealing the contents from the air. As the can and contents cool and the contained steam condenses, the top and bottom of the can assume a concave form, due to the creation of a partial vacuum inside the can and the operation of atmospheric pressure. A can is said to be 'blown' when from any cause the entrance of air, and with it microbes, takes place. The contents of such cans are liable to give rise to acute poisoning from ptomaines or toxins. Most toxins are destroyed by boiling for some time, but there is at least one toxin, due to a bacillus which is sometimes found in flesh meat, which is not destroyed at the end of one hour's boiling.

In surgical work the sterilization of the hands of the operator, of instruments, and of the part about to be operated upon, is absolutely essential before operation if the best results are to be expected. [J. GI.]

Sterilization of Milk.—By sterilization is understood the freeing of milk from all living micro-organisms, which in ordinary practice get into it from the moment it leaves the udder of the cow, and in cases of diseased udders sometimes before the milk is drawn. Even with the greatest care, the exposure to air, the passing through well-cleaned milk vessels, and all the other operations of the farm and dairy which the milk undergoes, as well as the subsequent distribution to the consumer, add their share of fresh microbes to this highly nourishing liquid, in which a very large number of them find a most suitable medium for their rapid development. Fortunately the disease-producing organisms are few in number and comparatively rare, but there are many organisms which produce changes in the milk which spoil its flavour and soon turn it sour.

Sterilization aims at the complete destruction of all these organisms, and such a result is most satisfactorily brought about by the agency of heat, either alone or, as has sometimes been suggested, with the help of certain gases or chemical substances.

This object can only be realized by heating the milk to a very high temperature, and where perfect sterilization has to be ensured it is necessary to heat the milk for two hours at a temperature of 120° C. (248° F.), or for thirty minutes at a temperature of 130° C. (266° F.). Such a temperature would be necessary to kill resistant spores in dirty milk and to prepare it for use in a bacteriological laboratory. Provided the milk is clean to start with, a lower temperature may safely be used, 120° C. for fifteen minutes in the autoclave usually sufficing to make clean new or separated milk quite fit for bacteriological use. Milk heated to such a high temperature is discoloured, and is quite unfit for commercial purposes on account of its burnt taste. The opposite extremes of temperature belong to the subject of pasteurization (see art. PASTEURIZATION), but it is important to note that many bacteria without spores can be killed at temperatures between 140° and 158° F., while the death of the tubercle and other pathogenic organisms will take place in milk if it is heated to 80° C. (176° F.), provided that all the milk is heated to this temperature, including the froth formed during heating. This is by no means an easy matter, and so with milk which is believed to contain any disease germs sterilization is to be preferred to pasteurization. In practice, milk which has been heated as high as or higher than the boiling-point of water, 100° C. (212° F.), is said to have been sterilized; and although, as mentioned above, it will not as a rule be free from all living spores of micro-organisms unless this temperature has been much exceeded, it will as a rule keep a considerable length of time without undergoing any changes in composition, more especially if the operation has been conducted in bottles which have been sealed up while the milk is still at the boiling-point. Most germs require some air for their development, and the spores which are usually present in the milk will not grow in the closed bottle. Milk prepared in this way will keep, even for months, and if the fat globules have been broken down, that is, if the milk has been 'homogenized', to prevent the cream rising, a very useful and lasting product can be obtained.

There is, however, little doubt that as a food sterilized milk compares unfavourably with fresh milk; it has a tendency, if used largely as an article of diet, to produce scurvy and also rickets in children; it also has a cooked taste which is objected to by many, and is more or less of a brownish colour.

The following chemical changes take place in the milk on sterilization. The albumen is rendered insoluble, precipitation beginning at 70° C., while no soluble albumen is found in milk which has been heated to 80° C. The estimation of the albumen, which should be present to the extent of 0·35 per cent in the soluble form, serves as a means of estimating the presence of sterilized milk in new milk.

The enzymes are destroyed at a temperature of 80° C., and so are absent from sterilized milk. The catalases evolve oxygen when 10 c.c. of fresh milk are shaken with 10 c.c. of hydrogen peroxide; this is partly caused by the natural enzyme of the milk and partly by those produced by bacteria.

If fresh milk is mixed with a little hydrogen peroxide, and then a solution of gum guaiacum in either alcohol or acetone is poured on the surface of the liquid, a deep-blue ring will form where the liquids meet. In place of the guaiacum solution a little ortol may be shaken up with the milk and hydrogen peroxide, in which case a red colour is produced; or if a little para-phenylene-diamine be added, a blue colour will be formed. All these tests depend on the presence of enzymes in the milk, and no colour will be produced if the milk has been heated above 80° C.

At about 100° C. calcium citrate is deposited.

It is probably due to the deposition of salts and albumen on the surface of the fat globules that the cream rises so slowly in milk which has been sterilized; but as the fat globules tend to run together at a high temperature, thick cream, and even butter, may form on the surface of bottles of sterilized milk in course of time, unless the milk has been well homogenized. The fact that a very small proportion of the cream rises on sterilized milk in the course of six hours may be used as a means of distinguishing it from new milk.

Sterilized milk cannot be used for cheese-making, as it does not respond to the action of rennet, this being probably due to the deposition of the calcium salts. A better precipitation with rennet may be produced by adding soluble lime salts if the milk has not been too much heated. The destruction of the natural enzymes and the precipitation of the albumen and soluble lime salts make milk which has been sterilized of less value as a food than unheated milk.

Partial peptonization may to a certain extent overcome these difficulties, and yields a product suitable for infants who cannot digest cow's milk. The milk is also so prepared as to more nearly resemble human milk in composition. Sterilized milk can also be used for the growth of pure cultures of the Bulgarian and other lactic ferments for food, but it does not give good results if used for the growth of pure lactic organisms for use as starters for butter and cheese making.

Various forms of apparatus have been invented for the sterilization of milk on a large scale, and modern improvements, such as the removal of oxygen before heating, and its exclusion during heating, have resulted in the emergence of a product with a better flavour than formerly.

The success of sterilizing milk depends very largely on the handling of the milk before it comes to the sterilizing apparatus, and it is absolutely necessary that only very clean fresh milk should be used if a satisfactory product is to be obtained. It must also be remembered that milk which has been sterilized offers a field for the growth of many undesirable organisms free from the competition of the natural lactic ferments, which often crowd out other taint-producing organisms. For this reason, machines in which the milk is sterilized in bottles, and in which the bottles can be closed before the tank is opened, are to be preferred. The bottles are arranged on a perforated drawer, run into a large metal tank which can be tightly closed by means of a heavy door. Steam is next admitted, and the temperature raised to a little above the boiling-point of water; after half an hour or longer the bottles are closed, and cooled in water which must first be hot and only progressively lowered in temperature or the bottles will crack. As the milk cools, a small vacuum is left in the top of the bottle, which can be tested by giving the bottle a sharp rap with the hand, when a sharp click like that of a water-hammer will be heard.

Other machines, such as the 'regenerative heater', may be used for sterilizing the milk in bulk, the hot milk flowing past the entering cold milk and so saving steam.

Sterilized milk has little to recommend it except in cases where it can be kept for a considerable length of time without undergoing any change, that is under conditions which prevent any subsequent infection taking place. [J. GO.]

Steropus madidus.—This is a ground beetle, one of the Carabidæ. It is shining black, the legs with reddish bases. In length it varies from ½ to ¾ in. It is very active at night and wanders about, amongst moist vegetation for preference. Curtis records it as feeding on wireworm, and thus as beneficial.

It has since, however, been found feeding on strawberries with other species and doing considerable damage. Where this is the case the beetles may easily be trapped by placing jam-pots or pudding basins in the soil, the tops level with the surface of the ground, and baiting them with meat and sugar water. The beetles fall or crawl into these traps with other strawberry ground beetles, and so can soon be exterminated. [F. V. T.]

Steward.—The farm steward is one who acts as the farmer's chief assistant in the management of a farm, and he is responsible generally for the execution of the details of the work; in certain districts the name 'bailiff' or 'grieve' is used in place of steward. On estates, the name 'land steward' is applied to the person who has general management of the home farm, pastures, woods, &c., and he is responsible to the owner, or to the latter's agent or factor.

The usual duties of a farm steward are varied and numerous. He receives instructions from the farmer as to the general cropping of the farm, and then sees that the cultivation of the land and the harvesting of the crops are carried out in a satisfactory manner. He superintends the mixing and application of artificial manures, the sowing of the various crops, has the keys of the granary and food store and keeps the records of the grain threshed, with full particulars as to the amount used or delivered to purchasers. The horse labour and piecework are directly under his management. He may have to engage ploughmen, and to procure the extra hands required on special occasions—turnip-thinning, haymaking, harvesting, &c.—portion out work to them, see that they do it, and pay them when it is finished. Ploughmen and wagoners are always under his control, and take their daily orders from him.

The steward usually has a house close to the

farm buildings, and is at all times the most important farm servant, and often capable of giving valuable advice on difficult questions of management. [J. M.]

Stiff Joint. See ANCHYLOSIS.

Stifle Joint.—This joint corresponds to the knee of the human subject. In front of the lower end of the femur, and upper one of the tibia, an irregular-shaped bone called the patella is found, having a close resemblance to our kneecap, and like it capable of being moved from side to side more or less when the limb is not flexed. The lateral ligaments are very liable to strain, and partial luxation of the patella is of frequent occurrence. Many weakly and overgrown colts are defective in this joint, and when walking the bone slips out and returns with a peculiar clicking noise. Placed in a small level paddock and well fed, the majority outgrow the trouble without treatment. [H. L.]

Stilopyga orientalis (the Cockroach).—This insect, improperly called the black beetle, is too well known to require any description. It swarms in kitchens, bake offices, &c., where it eats the bread, and will nibble shoes, harness, and a great variety of household articles. The males are winged, but the females are apterous; they lay a purselike bag of sixteen eggs, from which the young hatch, and immediately run about in search of food. Spirits of turpentine, or wafers compounded of red lead and flour, will destroy them. See COCKROACH. [J. C.] [F. V. T.]

Stilton Cheese.—Stilton cheese is a product from whole milk, and is one of the few varieties of blue-veined cheeses which are made in this country. It may be said to be the finest of all the varieties of British cheeses. The Stilton-making industry originated over 130 years ago. About that time Stilton cheese could only be purchased at the high price of 2*s.* 6*d.* per lb. at the famous Bell Inn, Stilton, Huntingdonshire, on the Great North Road from London to Edinburgh. In those days it was sold in the form of a rectangular cheese of small dimensions, and it was sometimes called cream cheese and also brick-bat cheese. Cooper Thornhill, the proprietor of this famous Bell Inn, had relations in Leicestershire, and one of them—a Mrs. Paulet—took up the business of Stilton-making at a village called Wymondham, near Melton Mowbray, in Leicestershire. The Stilton industry grew and centred round Melton, and now this town is the centre of a great Stilton-making business.

From the dimensions of a cream cheese the Stilton has by degrees grown into one which now usually weighs from 12 to 15 lb. A full-sized cheese is made from 16 gal. of milk. Such a quantity of milk would make 14 lb. of ripe Stilton. The Stilton is a tall narrow cheese of 9 to 10 in. height, and 7 to 7½ in. diameter, and it is not made in any other shape. Its crust is of a drab colour and presents a crinkled appearance. The crinkled surface is soft, and is liable to fracture during transit; and this is no doubt one important reason why the importation of Stiltons has not as yet been attempted.

The interior of the cheese should show a luxuriant growth of blue mould from the centre to the crust. The blue mould *Penicillium* and occasionally *Aspergillus* will be found to spread through the cheese in veins. The parts not blue-veined should appear as white as possible.

The Stilton has undergone a series of changes in its methods of manufacture. In the first place it was made from milk enriched with hand-skimmed cream, while in later methods it was made from mixed milk composed of morning's milk and that of the previous evening. Here we have ripe milk. The milk of the previous evening was put into leads provided with plug holes for drawing off the skim milk from under the cream. Some of this skim milk was drawn off and withheld from the milk for cheesemaking; thus the evening's milk was enriched.

In present-day methods added cream is not now used for enriching the milk, and Stiltons are most successfully made from whole milk containing only its own cream. Makers have proved that the experiment of adding freshly separated cream to the milk for Stilton cheesemaking does not produce such good results as those obtained from normal new milk.

For many generations Stiltons have been made on the two-curd process, viz. a process in which a curd of 36 hours is mixed with one 8 hours old. This method is practised to some extent at present, but it is being partially replaced by the single-curd process, where the curd is all of the same age when put into the moulds.

This latter process occupies from 24 to 30 hours, and the evening's milk contributes towards a batch of cheeses distinct from those made from the morning's milk. The latest introduction into Stilton-making methods is the making of cheese from ripe milk. The term 'ripe milk' may here be described as a mixture of morning's milk and milk of the previous evening. Such a mixture would contain an appreciable trace of acidity. In this practice it will be found necessary to adopt a 12-hour process, and to facilitate whey separation by cutting the newly coagulated curd.

The present methods of manufacture will be found to vary considerably even in the Stilton district proper. Different soils call for different processes, and variations have to be made according to the influence of local conditions.

Whatever may be the nature of the soil and other local conditions, the maker must strive to have these qualities in his curd at the time of vatting:—

1. A curd possessing good flavour, and free from flavours which are unnatural to milk which has been produced and handled under strictly cleanly and hygienic conditions.
2. A curd containing a definite amount of acidity.
3. A curd possessing a suitable amount of moisture.
4. A curd of loose texture.

In short, there must be present right proportions of acidity and moisture, and the curd must be in such a condition that it will not blend closely together. These are conditions necessary for the successful propagation of blue mould in a cheese.

STILTON CHEESE

METHOD OF TIGHTENING STRAINING CLOTH — LADLING THE CURD — STRAINING CLOTHS CONTAINING CURD

Methods of manufacture recorded in books coincide more or less with Melton Mowbray methods. The milk produced round Melton may be said to be milk which keeps well, and it is in dairies where milk possesses this property that the Melton methods are to be adopted. It may be accepted that such methods largely comprise the single-curd process (24 to 30 hours), and for all practical purposes this may be regarded as the orthodox method of Stilton cheese-making, although it must be pointed out that where milk does not possess keeping qualities the 30-hour process would be quite unsuitable. Such a milk calls for the adoption of either the double-curd process or a process of 8 to 12 hours. There is no doubt that the best Stiltons are made from long-keeping milk, which produces a curd retentive of moisture.

Milk which does not keep well produces a curd in which there is excessive contraction and consequently excessive whey drainage, the result being a cheese lacking in moisture. This lack of moisture impresses the consumer, and indeed sometimes the cheese merchant, that the cheese is wanting in fat, and it is designated as 'lacking in quality'. Such a fault is invariably due merely to a deficiency of moisture. The want of moisture is mainly accountable for those chalky-textured Stiltons which do not go blue, and on which much precious port wine is wasted. Such cheeses will not grow blue mould either by skewering or by applications of wine. Cheeses which are moist, open in texture, and fairly acid, will successfully develop mould in a moist room without resort to any artificial means.

On farms where twenty to thirty cows are kept the Stilton dairy usually comprises four or five compartments. The making room, about 5 by 4 yd., in which the important work is done, requires to be kept at a constant temperature. There are two ripening rooms: one for new, and one for older cheese. Such rooms are preferred with concrete floors, which simplify the maintaining of moisture in the room. Concrete floors also serve to discourage the accumulation of mites and cheese flies. A somewhat draughty room on the ground floor is set apart for the drying or coating of new cheese. There should be effective means of regulating the heat and light in all the apartments. A northern aspect is preferable for all cheese rooms, whatever may be the variety stored, in that high temperatures in summer, which are difficult to control, may permanently ruin a large stock of cheese.

A temperature of 63° F. is recommended for the making room and 60° F. for ripening rooms. In this business wet floors are inevitable, and such floors should have a fall of 1 in 48. The dairy should be fairly lofty and well ventilated. The windows of a Stilton establishment are frequently protected with fine wire gauze, which will not admit the cheese fly.

The following is a list of the utensils used for Stilton-making:—

Setting pans—gauged to 15 or 30 gal., in which the milk is renneted.

Scoops for removing the curd into cloths which lie in the draining trough or sink.

Cloths 1 yd. square made from straining cloth. These cloths hold 2 to 3 gal. of curd.

Draining troughs, which hold the bundles of curd. The trough may be of tin, tinned iron, earthenware, or brick. It is fitted with a plug for the drawing of the whey.

Curd sinks or leads into which the curd is emptied from the cloths.

Moulds with open ends for the shaping or vatting of the cheese. Each mould stands upon a circular board.

Tables for sundry work.

Curd pans for weighing and salting of curd.

Weighing scales.

Measuring glasses and rennet.

A large copper is indispensable as a means of supplying hot water.

The following is a short description of the process by which a Stilton could be made on the single-curd method:—

To Make One Stilton

8 a.m.—16 gal. of fresh morning's milk at 85° F. are taken, and rennet is added to coagulate it in 1½ hour. 4 dr. of commercial rennet are necessary, and about 32 dr. of home-made rennet.

10·30 a.m.—The curd is ladled into five or six cloths which lie in the draining trough. These cloths are not tightened for an hour at least, neither is the whey allowed to run off during this period. Acidity in whey ·12 (·12 per cent lactic acid).

11·30 a.m.—Cloths slightly tied.

12 a.m.—First accumulation of whey allowed to run off.

1 p.m.—Cloths again tightened slightly; whey allowed to run continuously.

3 p.m.—Cloths again tightened; the bundles being turned over.

5 p.m.—Curd emptied out of cloths into curd trays. Acidity ·15. Whey kept on the curd overnight. The draining trough is now free, and a similar process can be commenced with the evening's milk.

7 a.m. next day.—Whey drawn from curd trays. Curd cut into 4 in. squares and turned to facilitate drainage.

9 a.m.—Acidity in curd, ·4. There should be 28 to 30 lb. of curd. Curd weighed, broken by hand, and salted at the rate of 1 oz. salt to 2½ lb. of curd.

9·30 a.m.—Curd lightly placed in mould; no pressure applied when filled in. The mould, 14½ in. by 8 in., will be quite full of curd. Cheese turned directly afterwards and again later in the day.

This cheese will occupy six to ten days in draining. No mechanical pressure is applied. It will be turned once daily during this period. When sufficiently drained it will shrink from the sides of the mould, and will almost hold its shape without the support of the mould.

The rugged surface is scraped to a smooth condition with a knife. This is repeated again on the following day, but the knife must not be applied again if a crinkling formation has commenced. On each occasion when the surface is scraped, a calico bandage is pinned on and the mould replaced.

On the third day after the smoothing of the coat the mould is removed for good. The cheese is placed in the coating room, in which there is a free supply of ventilation. In fourteen days the cheese should become dry and white in appearance. The characteristic crinkle should have formed. On each of the first four days of this drying process, the cheese is bandaged afresh with a dry bandage. For the first three weeks the sides of a new Stilton must not be handled with the hand. This will destroy the crinkle.

The handling and turning must be done by the help of boards placed on each end of the cheese.

A well-made cheese, kept at a temperature of 60° F., will occupy five months in maturing. It is turned daily during its history. Unshapely Stiltons are usually termed 'weak'. They are rich and moist, and frequently develop the growth of mould. They ripen early, but rapidly decay. Stiltons which are very shapely and straight in their lines are frequently dry and 'chalky'. The 'weak' condition is due to insufficient acidity in manufacture, while the chalky condition is due to an excess of acidity.

In striving to arrive at the medium condition of acidity the maker frequently has a considerable percentage of cheeses in his storeroom which are under or over the mark. This all means loss to the maker, and this is one of the reasons why the high prices for good Stilton are maintained.

From the foregoing it will be seen that throughout the process the temperature of the curd was not raised above renneting temperature. The curd has lain about in a wet condition for a period of over twenty-four hours, and at vatting it is somewhat of a sloppy creamy texture and distinctly acid. During this period of exposure the curd will have collected much germ life from the air, including mould spores; but whether the spores introduced at this period hold good for germination in the later ripening period remains yet to be proved.

Stilton makers hold the view that the spores which originate in the main, the growth of *Penicillium* in the cheese, are those introduced to the cheese in the cheese room in the early ripening stage when the cheese contains an abundance of moisture. [M. B.]

Stimulant.—Anything which excites organic action or calls forth latent energy without subsequent corresponding depression or reaction is called a stimulant. Some things, like alcohol, stimulate in small doses but act as narcotics in large ones. Heart stimulants, or vascular stimulants as they are called, accelerate the circulation of the blood: alcohol, ammonia, and camphor, for example. Stomachic stimulants are more often termed carminatives, but are true stimulants: ginger, mustard, capsicum, are among those employed by veterinarians. Spinal or nerve stimulants are represented by such drugs as nux vomica and its alkaloids. Cold is a stimulant to the skin, and the new born are exposed to it in order to set the heart and lungs in operation by reflex action. Heat under other circumstances may be employed as a stimulant, as may electricity. Mercurial preparations are counted as liver stimulants, and nitre as a kidney stimulant. [H. L.]

Stinking Mayweed, or **Stinking Chamomile,** the popular names for a composite weed with a fœtid odour, commonly found on cultivated land and in waste places. See CHAMOMILE.

Stipa tenacissima, L. (the Esparto, Alfa or Halfa Grass; nat. ord. Gramineæ).—This is a native of Spain, Italy, and North Africa, between 32° and 41° N. latitude. It, or perhaps rather the allied grass *Lygeum Spartum*, was used in ancient times by the Romans for cordage, but to an Englishman—the late Mr. Thomas Routledge of Sunderland—is mainly due the honour of having discovered its great merit as a paper-making material. In 1839 the first effort was made to work it up, and in 1851 paper made of it was shown at the Exhibition of that year. Up to 1861 Routledge was the only paper-maker who used Esparto, and even to-day it is mainly utilized by British manufacturers, and chiefly for the paper required for printing, its excellent surface taking printer's ink in fine lines and half-tones. Although longer than straw, Esparto is classed as one of the shortest paper fibres (as compared with cotton and linen), but owing to its very small central canal it is non-collapsible—a feature of great value. The ends of Esparto fibre are moreover solid, and get compressed into a hexagonal form, so that in transverse section, as seen under the microscope, they resemble a honeycomb. Esparto is shipped from Spain, Algeria, Tunis, Tripoli, and formerly from Morocco, with smaller amounts from other countries where the plant is now cultivated. It grows in great clumps and requires little cultivation, at altitudes ranging from the sea level up to 3000 ft. It flourishes on sandy and rocky soils, and can do with remarkably little rain. During harvest the dry ripe leaf is simply pulled from the sheath by the hand, and the blade then curls around the midrib into slender reedlike structures, thus carrying the characteristic minute hairs of the margin to the interior. If properly treated the clumps may yield an annual harvest for thirty to fifty years; but unless the grass be gathered at the exact stage of maturity, Esparto yields an inferior pulp, and if shipped with a mixture of roots or other dirt it is greatly depreciated. If loosely baled it occupies from four to five 'tons measure' to every ton in weight, but when properly baled with iron hoops it may be compressed into half that space. The reader will find a long and highly instructive article on this fibre (written by Mr. Clayton Beadle) in Technics for May, 1904, while Messrs. Ide and Christie's monthly Circulars will be seen to give full particulars of the trade. The imports into Great Britain have fluctuated since 1903 between 190,227 and 202,523 tons in 1908. During 1909 they stood at 193,853 tons, with the price ranging from £4, 10*s.* to £4, 15*s.* for the best Spanish, and £2, 12*s.* 6*d.* to £2, 15*s.* for fair Tripoli per ton. [G. W.]

Stoat, or **Ermine** (*Mustela erminea*), a member of the weasel tribe, fairly common throughout the British Isles, and especially abundant in Scotland. It is larger than the weasel, and has a relatively longer tail. A full-grown male measures 10 to 11 in., the tail 5 to 6 in. The female is considerably smaller. The colour is reddish-brown on the upper parts, white with a tinge of yellow except on the throat on the under parts. The tip of the tail is black. In at least the northern parts of its range, the stoat's fur changes to white in winter, the tail tip remaining black. In this condition it

forms the well-known ermine of commerce; but the fur of the short-haired British ermine is not nearly so valuable as that of some of the longer-haired races of Northern Europe and America, and large numbers of these are imported annually. In the south of England and in Ireland the colour change rarely takes place, and even in Scotland it may be delayed greatly by a spell of mild weather. The change is due, according to Macgillivray's observations, to the sprouting of new white hairs, and not, as in the mountain hare, to a change in the existing fur. The new growth of hair may be red if the weather be unusually mild, and 'if there are alternations of severe cold and temperate weather, the animal may become mottled'. All stages of transition between winter and summer colouring are found.

The stoat frequents thickets, stony places, old walls, or any locality which affords it suitable cover. It is extremely active and courageous, taking readily to the water and climbing trees after its prey. It tires out its victims by the relentless persistence of its pursuit, and even animals much larger than itself become paralysed apparently from terror and exhaustion when pursued by a stoat. It feeds largely on voles, of which it destroys enormous numbers; but it also eats young hares, rabbits, and game birds, and may occasionally raid poultry yards, destroying or carrying off both chickens and eggs. Of late years the stoat has been introduced into Australia in the hope that it may prove a check to the excessive multiplication of the rabbits. [J. A. T.]

Stock (Matthiola).—A genus of Cruciferæ comprising hardy, half-hardy, and tender annual, biennial, and perennial herbs or subshrubs. Stocks are cultivated in almost every garden. There are several sections and many varieties. The flowers are variously coloured and deliciously scented. The summer-flowering Ten-week Stocks are derived from *M. annua*, and these plants have lately been greatly improved. The Wallflower Stocks, which have shining, smooth green leaves, are forms of *M. incana*. Other popular winter-flowering sections are the Large-flowered, the Pyramidal, the Intermediate, and the East Lothian Intermediate. In order to become big, floriferous plants, Stocks require rich soil. The seeds, which germinate best when they are new, should be sown thinly in pans or boxes containing sandy soil, the Ten-week Stocks in March or April, and the others not later than early in July. Over-watering causes the seedlings to damp off, and they require plenty of light and air from the first. They may be pricked off into a bed prepared in a cold frame, and the transference to the open borders should take place during showery weather. Intermediate and East Lothian Stocks are particularly well adapted for cultivating in pots. Old mortar should be mixed with the compost, and manure water given when the flower-buds are developing. Stocks kept in frames through the winter should be planted out in March. The so-called Virginian Stock is *Malcolmia maritima*, one of the prettiest and most popular of hardy annuals, which will flower, sow itself, come up, and bloom again in the same season. [W. W.]

Stock. See LIVE STOCK.

Stock-breeding. See arts. BREEDING, LAWS OF; CATTLE-BREEDING; HORSES—FEEDING, REARING, AND MANAGEMENT; PIGS, BREEDING OF; POULTRY BREEDING, and articles on various breeds of live stock.

Stock Dove (*Columba œnas*).—This bird is about 13 in. in length, and its plumage is bluish-grey, with an imperfect bar on each wing. The legs are pink, and the bill white at the tip and red at the base. The food consists of seeds, partly those of weeds such as Charlock, but also to a large extent of cultivated plants. It must be regarded as mainly harmful. No nest is built, but the two buff-coloured eggs are laid in a hole in a tree or cliff, the old nest of some other bird, or even in a rabbit burrow. [J. R. A. D.]

Stocking of Farms.—Although the expression 'stocking a farm' is closely related to that of capital, there are many questions connected with the description and quantity of both live and dead stock which require serious attention. In the article on CAPITAL a typical case is given, and the reader is advised to consult it, and to make such modifications in numbers and prices as may be applicable to his own case. The farm there chosen for illustration is of moderate size, and the arable land is supposed to be worked on the four-course system. The 400 ac. of plough-land includes 200 ac. of corn, 100 ac. of roots, and 100 ac. of clover; but it is evident that this division need not be followed, and that a very different rotation and apportionment between corn and live stock may be contemplated. This would affect the number of horses, the quantity of seed and of artificial manures required, the labour bill, and many other items connected with capital. It therefore appears necessary to add an article on the stocking of farms. It will be seen that under the heading CAPITAL the case of a Scotch hill farm is given, and also a market garden; and these three examples give an idea of the varying amounts per acre required under different circumstances.

At present it is intended to enlarge upon the middle case, as representing the majority of holdings in Great Britain. So far as the pecuniary aspect is concerned, it will be sufficient to adapt the figures given under CAPITAL to any particular farm, according to its size, its capabilities, its situation, and the objects of the prospective tenant.

The stocking of a farm includes a large number of items, as is indicated by the expression 'live and dead stock', and it would be unpardonable to omit the latter in the present connection. Dead stock might be regarded as referring only to implements of husbandry and machinery, with appliances such as tools and utensils, enumerated under CAPITAL. It, however, includes much more, because no one should enter on a farm without setting aside a sufficient sum for labour and other expenses that must be incurred before any considerable return can be expected. There are also the acts of husbandry performed by the outgoing tenant for the benefit of his successor

which must be met, as well as compensation for the foods consumed by his stock during the previous year or two. The payments to the waygoing tenant must appear as a portion of farm equipment, whether regarded as dead stock or as invested capital, and for this reason constitute important items in stocking any farm.

Another class of liabilities or of outlay includes the first year's, or half-year's rent, rates, and taxes; and, what is often forgotten, household furniture and expenses, which vary with the position and habits of the tenant. If the farm were viewed as a business, like a manufactory or a shop, it might be thought unnecessary to mix up private expenditure with capital. But in the case of the ordinary farmer it would be a mistake to forget that a not inconsiderable amount of his capital must be expended upon furnishing his house and defraying his personal expenses. It seems, therefore, evident that the stocking of a farm involves a sufficient fund to provide all the objects summarized under the head of CAPITAL (vol. iii, p. 96) and indicated in the above remarks.

Live Stock, Number of.—Overstocking is a grave mistake. The head of stock should be adapted to the capability of the farm. Overstocking entails perpetual anxiety as to keep, and a certain sacrifice, if, owing to failure of roots, grass, or hay, the owner is obliged to sell. In such cases stock is sure to sell badly, because keep is *generally* dearer. On the other hand, if a farm is moderately stocked, the farmer can buy cattle or sheep when an opportunity offers; as he can hold his stock over periods of scarcity, which are often followed by a rebound to higher prices at no distant date. The overstocked farmer may, it is true, sell out when prices are high, but this he probably will not do if he has plenty of keep and prefers to maintain his stock. It behoves every good farmer to stock his farm according to its area and character, and to see that his animals are supported for the most part upon the natural produce of the land.

Selection of Stock.—No greater mistake can be made by a beginner than keeping the wrong sort of live stock. This matter requires to be very carefully considered, but a safe guide is found in the practice of the neighbourhood. The established farmers of a district have gradually come to a conclusion as to the best class of stock for their particular land, and he is a bold man who ventures to introduce a new system. A man may have views as to horse-breeding, but would be ill-advised to take land in any part of the country unless fit for his purpose. The mistakes usually made are of a less glaring nature. They do not so much consist in stocking with cattle when sheep ought to be supreme, or insisting on breeding colts on land unfitted for developing bone. They are committed within narrower limits, and often without changing the species of the animal. In stocking a farm it is of the utmost importance that fattening should not be attempted on breeding land, or the reverse. The greatest judgment may be displayed in selecting and buying stock, and the highest science may be lavished upon feeding and management; but if it is the wrong sort of stock, all these efforts will come to naught. This is a practical fact, and also involves a common error. The neighbours know; but the person most concerned may not find out his mistake until it is too late. The fact is, that he has made a wrong choice as to the stock fit for the land. He should have kept a flock instead of attempting to fatten tegs. Or, he should have maintained cow stock instead of steers. Or, he should have laid in a hardier class of both cattle and sheep, and not indulged his fancy for highly bred animals. Classes of live stock are much more numerous than might at first sight appear. It is not merely a matter of horses, cattle, or sheep, nor yet of breeding versus fattening. Cattle and sheep ought always to be brought from poorer into richer land, or off high and exposed situations into lower and more sheltered ones. The judicious buyer selects animals which have been raised on poor land, feeling confident that they will improve in the situation to which he is taking them. Pampered animals should be avoided, and lambs that have lived hard and been kept without cake and corn should be preferred to those which have been caked for the butcher rather than for the grazier.

All animals appreciate an improvement in herbage and climate, and this fact should be kept steadily in view in stocking a farm. One of the commonest experiences is, that stock often do badly the first year. The writer has seen it frequently in the case of beginners. A man buys, say, ewes, and encounters an unfortunate lambing time; or cows, and meets with disappointment in the yield of milk, or it may be in the form of premature births and dead calves. This is due to several causes, the first of which is a change of locality, which frequently affects animals. The second is, that the best animals are not always those sent to market. Animals exposed for sale may be drafted stock, sold because they are not entirely approved. They may appear cheap, but are not so in reality. The third cause is the newness of the master and his men, who have not as yet quite mastered the peculiarities of the farm. It is for these reasons wise to buy at displenishing sales, where the entire stock is sold off at once, rather than at fairs, markets, or draft sales. A newcomer to a neighbourhood is particularly liable to misfortunes, because he is not quite conversant with the district and its markets.

Choice of Implements.—The amount of capital which may be expended in purchasing implements is prodigious, and might easily absorb the whole sum. Implements, however, ought not to represent more than about one-tenth of the farmer's capital, and, in order to keep the outlay within bounds, the beginner ought to frequent sales. It is considered by many good business men that new implements are cheapest in the end, and this is probably true. When, however, capital is limited in amount, it is necessary to husband it; and if good serviceable ploughs can be bought at a sale for £1 each, it seems foolish to give £5 for them new. It is the same with carts and wagons, and all other implements; and at a good sale, where the stock and implements are of a high order, purchases should be made.

There is also the question of the more expensive and elaborate machines; and on this point it is recommended that a beginner should purchase as few of them as possible. In these days, steam cultivation can be carried out on the contract system, and the same is true of threshing and chaff-cutting. Cake can be bought ready crushed, and beans already kibbled or ground up. Even meal can be ground at a trifling cost; and by taking advantage of these modern facilities, hundreds of pounds of capital may be saved. Let anyone put down the cost of a portable engine and threshing machine, chaff cutter, cake breaker, mill, &c., and he will soon account for £1000, and still more if he includes a set of steam-cultivating tackle. So-called labour-saving machines are very attractive, but should not be purchased unless they actually lower the cost of labour, horse or manual. In many cases they do not, as exactly the same number of men, lads, and horses are required on the farm as were necessary previously. The questions of efficiency and rapidity are, of course, important, but the writer entertains a strong objection to labour-saving implements which save no labour, as represented by wages and horse keep during the year.

Michaelmas and Lady Day Entries.—The usual time for entering farms in England is September 29, or Michaelmas Day, and in Scotland, Martinmas, November 11, and Whitsunday, May 15. In some districts of the west of England old Michaelmas, or October 11, is still observed, especially in engaging farm servants. Lady Day, March 25, is also a favourite term day, and possesses the advantage that business is commenced just before the grazing and growing period of the year. Less capital is necessary for a Lady Day than for a Michaelmas entry, as the tenant will reap a harvest within six months of entering his farm, and he also comes into the immediate receipt of all the returns from grazing, dairy produce, wool, poultry, &c. Neither is he called upon to spend money on cake and corn, and the farm is to a great extent self-supporting. Instead of disbursing money continuously for six or seven months during a dead season when little is produced from the land, he enters at once on a period of fruition which eases the strain upon capital. His first half-year's rent can be paid out of revenue, and need not be looked upon strictly as capital. These are palpable advantages, but in spite of their attractiveness the Michaelmas entry is in many respects preferable. It is no small advantage to be able to arrange cropping before the actual sowing time arrives; to make, and place, the dung where it will be needed; to cultivate the ground during winter upon the most modern principles, and to settle into possession in ample time for early sowing and arranging spring work. Still, more capital is needed, and the returns are either much slower in arriving, or they are produced at greater expenditure.

Methods of Entering Farms.—The two methods of entering on a farm are by valuation or by what is termed 'working in', and the latter plan is decidedly the most economical. It is usually adopted by men who are already settled in near proximity to the farm they have taken. In such case a farmer will perform his own tillages at a less cost than by valuation. Rights of pre-entry are granted in all cases to an incoming tenant both as regards Michaelmas and Lady Day entries. He is entitled to enter upon land intended for wheat, and to plough and clean stubble. In spring he can enter upon land cleared of roots, to sow spring corn and grass seeds, and the outgoer is bound to consume his fodder crops and roots in good time so as not to interfere with his successor's tillages.

In entering by valuation the outgoing tenant is supposed to carry on the cultivation of the farm as if he were remaining, and all the tillages and acts of husbandry expended upon root and fodder crops not yet consumed are valued on a prescribed scale. In some districts this scale is extremely liberal to the outgoing tenant, and in this respect it is objectionable to the incomer. It is true that as he enters so he quits, but it is possible that when this event occurs his successor may elect to work himself in, and save the tillages. There is, however, little choice in the case of a stranger from a distant county, or in that of a young man beginning business who has neither horses nor implements. Valuation is therefore a frequent method, and the process of entering is much shortened and simplified by it.

Landlord Primarily Liable for Tillages.—In all changes of tenancy the quitting tenant has a claim against the landlord for all acts of husbandry and improvements (see AGRICULTURAL HOLDINGS ACTS) which actually increase the rental value of the land. So far as tillages and compensation for foods and fertilizers are concerned, the landlord is also primarily liable, but in most cases the claims are paid by the incoming tenant as the person benefited by them.

Payment for Tillages not Dependent on Results.—It may appear at first sight unreasonable to be charged for tillages on a crop which has failed. It is, however, clear that no outgoing tenant would undertake the risks of failure due to the season. Unless it can be shown that due care was not taken in executing the tillages, the incomer must pay irrespective of the success of the crop. An entry is much more satisfactory when the roots are successful, but in valuing the tillages the weight of the crop is not taken into account. The principle acted upon is remuneration for work done, and the risk rests on the incomer, as it would have done had he worked himself in or been in the position of occupying tenant.

Barred Tillages.—No tillages are payable upon any crop which the previous tenant has realized. On this principle there are no tillages after corn, potatoes, or any crop sold off the farm. There are, however, half-tillages on crops partly realized, as when roots have been consumed upon the land, leaving the manurial effects for the benefit of the incomer. The method of estimating the value of half-tillages varies with the locality.

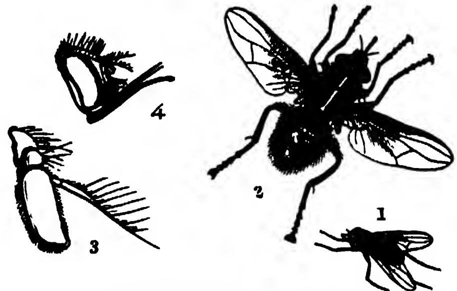
Compensation for unexhausted improvements over and above ordinary tillages includes payments for foods purchased, and home-grown corn fed on the holding; residual effects of lime, chalk, marl, &c., applied several years previous

to quitting; work done for which the incomer will receive benefit; and all improvements which are of distinct value to the landlord or the new tenant. See also arts. on CAPITAL; AGRICULTURAL HOLDINGS ACTS; &c. [J. WR.]

Stomach Staggers.—Both horses and cattle are liable to this disease, the symptoms of which differ very much from those described under the heading STAGGERS. A general tendency towards coma or sleepiness and a profound lethargy, rather than excitement or falling down in fits, mark stomach staggers. The horse swings his head outdoors and walks with a staggering gait. Some lower the head almost between the knees, and seem unable to go forward. In the stable the animal is more often found with his head pressed against the manger or a wall, with slow and laboured breathing, and corresponding pulse. Cows suddenly go off their milk, stop feeding and cudding, respiration is slow, pupil dilated, and a disposition to knuckle over on the fetlocks is observed. There may be some diarrhœa at first, but this is invariably followed by constipation—a symptom common also to equines. As the symptoms advance, snoring is noticed, and the animal appears to be blind; if at liberty, walking into collision with solid objects and seeming bewildered. That this form of staggers is due to overloading and acute indigestion having a special influence on the brain there is no doubt, but certain kinds of food give rise to it without perhaps being indulged in to excess. Rye grass which seeds prematurely in dry seasons, or excessive amounts of green rye corn, will produce it. Hot weather and scorched pastures and absence of sufficient water contribute to stomach staggers, but stabled animals sometimes suffer. *Treatment.*—Almost immediate relief follows on the abstraction of a few quarts of blood from the jugular vein. Purgatives are advised, but the bowels do not always respond at first, and care must be exercised not to excite superpurgation when the nervous energy has been restored and the peristaltic action resumed. [H. L.]

Stomoxys calcitrans, Linn. (fig. 1, the female; 2, magnified), is a two-winged fly, which is abundant in summer and autumn, tormenting cattle in hot and showery weather by piercing their legs and occasioning their continual kicking. It is also very annoying in houses, and exceedingly like the house fly (*Musca domestica*), being principally distinguished by its long and horny proboscis. It is grey or olive-brown, with black bristles; a glossy, whitish face, and a black stripe on the forehead; the drooping antennæ have feathered bristles (fig. 3, magnified), and the palpi are short; the eyes remote in the female, and brown; the proboscis projects nearly horizontally (fig. 4, the head in profile, magnified); the thorax has four black stripes, and the body is apparently four-jointed; the second and third segments with three brown spots, the fourth with only one; wings transparent, second cell open at the apex, third with a transverse nervure; balancers, ochreous; legs, slate-colour; knees, ochreous; expanse, seven lines.

This fly, also called the Storm Fly, enters houses mainly before and during rainy and stormy weather. The female lays her eggs in horse droppings and manure heaps, especially according to Newstead in heaps of grass mowings. The maggots are creamy-white and footless, like those of the house fly, and measure not quite ½ in. when mature. The larval stage lasts fourteen to twenty-one days, but may be retarded. The process of pupation takes about



Stomoxys calcitrans—Storm Fly

two hours, and then the puparium hardens into a barrel-shaped brown body, length about ⅛ in. [F. V. T.]

Stones, Building.—The requirements of a good building stone are resistance to atmospheric weathering, a low power of absorbing moisture, and a structure that allows of equable trimming in any desired direction. Extreme hardness, as in some quartzites, blunts the tools used to such an extent as to render the working of the stone uneconomic. Where granite lies near at hand, it forms a first-class building stone. Limestone and sandstone are favourite materials, owing to their uniform texture in considerable masses, and the comparative ease with which they can be worked. In selecting a building stone it is always well to examine the surfaces of old quarries where the rock has been long exposed to weathering, or, still better, the cut stones of old buildings or of dated tombs. [G. A. J. C.]

Stones, Building, Preservation of.—The susceptibility of stones to weathering becomes an important consideration when stone is employed for structural purposes. For ordinary stone walls dividing fields, all that is required is that the blocks shall remain in place one upon another; but the same stones, when used for walls fronting main roads and for farm buildings, require selection with far greater care. The smooth face and rectangular form imparted to stones used in building reduces the amount of surface exposed, and is in itself an aid to preservation. But even a well-trimmed stone betrays weakness after a time, especially by scaling of the surface; while limestones are especially subject to decay through irregular solution. Scaling is sometimes set up through the dressing of the face with unduly heavy tools, which jar some of the constituents into a loosened state. Preservation of the stone is then usually impossible. But frequent painting of the surface of sandstones that tend to scale, or to show irregularities due to internal structures, is often effective in the case of buildings

outside the atmosphere of towns. Oil and paraffin have been applied to various stones. Sylvester's solution, which is made by mixing ¾ lb. of soft soap in a gallon of boiling water, and adding ½ lb. of alum dissolved in 4 gal. of water, has been successfully employed, but, like paint, should be renewed. A highly scientific method is that of Ransome, in which calcium silicate, insoluble in water, is formed on the stone and in its interstices by soaking the surface with soluble sodium silicate (water-glass), and then adding calcium chloride. Sodium silicate or potassium silicate may be used alone, where there are calcium salts in the rock ready to combine with the silica thus supplied in a soluble condition. [G. A. J. C.]

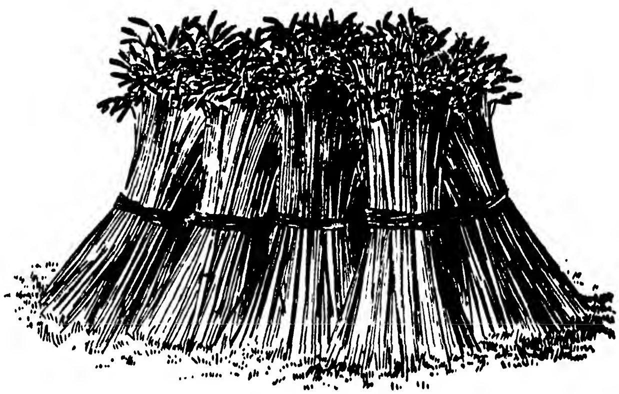
Stones in Soil.—The coarser more or less unweathered rock-fragments or stones which exist in most soils have an important influence on the fertility of the land in which they appear. By tending to diminish evaporation from the surface of the ground, stones economize the supply of soil moisture, and thus help to increase the capacity of the soil for crop production. Wollny showed that their presence in the soil also effectually raised its *mean* temperature, but that the same cause operated unfavourably by widening the *range of variation* of the soil temperature. On the whole, according to the same authority, the cropping capabilities of the land increase with the proportion of stones up to an optimum which corresponds with a stone-content of 10 to 20 per cent by volume of the soil, but beyond this proportion the fertility of the land diminishes. As stones possess but a small surface compared with their mass, they contribute very little plant food to the soil. They are likewise a hindrance in all arable lands to the passage of tillage implements; in clays, however, when they occur at depths out of reach of the plough, they can be of considerable advantage for the promotion of drainage. Stones increase in numbers at the surface of the ground from the washing away by the rains of the finer earth into the subsoil or ditches. [T. H.]

Stones in the Bladder. See BLADDER, DISEASES OF; CALCULI.

Stones in the Kidney. See KIDNEY, DISEASES OF.

Stooks and Stooking.—A stook is a collection of sheaves of grain or other crop, set up in the field for the purpose of drying the grain and straw. The word mainly belongs to Scotland and Northern England, the corresponding word generally used elsewhere in England and in America being *shock*. Grain of all kinds, and grass seeds, when harvested in most countries, are seldom sufficiently dry to be threshed or stored. In order, therefore, to promote drying, by exposure to the sun and air, the sheaves are set up on end, generally in lots of from six to twelve, each lot being called a stook or shock, and the work of setting up, stooking or shocking.

The sheaves are set up on end by placing two opposite each other, with their butt ends about 18 in. apart for short straw and 2 ft. where it is longer. The heads of the two sheaves are then brought together, each sheaf being firmly pressed against the other at the bands, so as to securely fix them, yet leave them in an upright position, but with sufficient slope at the sides to resist being blown over by moderate wind. The first pair or two pairs of sheaves which are set up, should always form the centre of the stook, and looked at from the side, they should stand perpendicular. Other pairs of sheaves should afterwards be placed at each end of those first set up, care being taken to set up an equal number of pairs on each side of the central pair. Each of these pairs should lean only a very little towards the central pair. The end of the stook



Stook or Shock of Wheat

should always face the prevailing wind of the district, in order that the current of air passing through the stook may more or less dry every sheaf in it, and also because a well-built stook withstands wind pressure very successfully from that direction. In Scotland the direction should be south-west and north-east, or to where the sun is about one o'clock. Stooks so set up get the sun on the one side during the forenoon, and on the other in the afternoon, which in a dull or late season is a great aid to uniform drying of the crop.

Seeded grasses, or very short grain, particularly if it contains grass or clover, should not be put up in stooks containing more than four or six sheaves, but long grain, and especially wheat, should have from ten to fourteen sheaves in each stook. In wet districts or in late seasons, hood sheaves are often put on the top of each stook. If of wheat, the sheaves are bound somewhat near the butt end, and placed on the top of the stook in such a position that the butt ends meet in the middle, where they are slightly pressed into each other and form the apex of the roof of the stook. Before being laid in position, the sheaves are slightly opened on the under side, so as to lie better on the top of the stook. Where oat stooks are hooded, the heads

of the sheaves are generally put to the centre of the stook. [J. S.]

Store Beetle, a small, brightly coloured beetle destructive to dried store goods, such as hair, feathers, wool, &c. See ANTHRENUS.

Store Cattle are lean animals intended for fattening, and are usually of any age from six months to two and a half years or three years old, and of either sex. At from nine months to a year old they are called 'stirks', and at eighteen months they are often known as 'six quarters'. Store cattle are, as a rule, bred on the higher and poorer farms of England and Scotland, and in the dairy districts of Ireland. In Scotland they come from the crofting districts and from the Highland glens, from which they are picked up by dealers in twos and threes. A small proportion come from Orkney and Shetland, and the best sorts of these islanders are highly esteemed by feeders. A considerable number of Ayrshire and Ayrshire cross bullocks are obtained in the south-west, along with some Galloways and Galloway crosses. In England the cheese- and butter-producing districts of the Pennine chain raise many fine stores of nearly pure Shorthorn blood, while the Border counties supply the incomparable blue-greys. From Wales come the black horned Welsh 'runts' so popular in the Midlands and round London. The great reservoir of store cattle, however, is Ireland, from which there flows a constant stream of all ages and qualities to be sold privately or by auction in the larger market towns of Great Britain. As a rule, store cattle are relatively higher in price than fat cattle, and the difference in recent years has generally been too small to leave much profit to the feeder. In many cases stores have been bought at a price per cwt. little if at all less than that of finished animals, thus rendering a profit practically unattainable. The management of store cattle depends on the age at purchase. Calves are kept in a thriving condition for a year or eighteen months, and 'six quarters', if home bred, may be finished off in six months, but are usually kept for a year or more if Irish. All older cattle are generally fed off as soon as possible. During the past five years the importation of Irish cattle into Britain amounted to 470,361 in 1904; 455,667 in 1905; 473,425 in 1906; 492,790 in 1907; and 528,386 in 1908. Of those imported in 1908, 458,794 were stores for fattening, 41,711 were milch cows, and 27,881 were springers; but in addition to the 458,794 stores there were 64,850 calves. The average price for first-quality store stock of Shorthorn type in August, 1909, were: Yearlings, £9, 18s.; two-year-olds, £13, 15s.; and three-year-olds, £17, 10s. [R. B. G.]

Storm Fly, a two-winged fly, very like the ordinary house fly, which torments cattle in hot and showery weather. See STOMOXYS.

Straightening of Marches. See art. MARCH FENCE.

Strainers, Milk. See DAIRY APPLIANCES.

Strangles, an infectious disease of equines with catarrhal symptoms at first indistinguishable from common colds, but usually associated with more depression and lassitude—a sign which increases with the formation of abscess in the glands, most commonly the submaxillary. A rise of temperature and general febrile conditions are noted. Colts at grass and between two and five years of age are the most frequent subjects, but horses of any age may have it. When stabled animals of mature years develop strangles it is usually in a less acute form, and has received the name of bastard strangles. There are periods in which the disease is specially active and more acute than others, and it is supposed that aerial infection is a common method of communication. The disease is of greater severity and increased infectivity in close quarters, as on shipboard and in dealers' stables. The period of incubation is from four to eight days, but conditions leading to ordinary catarrh may develop the malady in a day or two. The swelling under the jaw gives rise to symptoms of sore throat and difficulty of deglutition. At first the animal may be observed to nod the head towards the breast; later, he pokes out the nose as the space between the lower jawbones fills up with pus and becomes painful. During this period appetite is in abeyance, and temperature highest. In a simple uncomplicated case the abscess ripens in a few days, the skin is tense and painful to the touch, a soft place or 'point' (see ABSCESS) is discovered, and some measure of pain may be prevented and recovery hastened by the judicious insertion of the lancet and evacuation of the contained pus. So much injury results from premature incision of the swelling that it is better to leave it to break spontaneously if the operator is in doubt as to its ripeness. Although horses fall away in flesh and show evident signs of weakness during an attack of strangles, their recovery is usually rapid; and it is observed that they thrive so well upon a generous diet that many breeders do not regard strangles as an unmixed evil, but credit the abscess with eliminating some morbid material from the body, to its advantage. Good hygienic conditions are important, and colts should not be allowed to bunch up together in a dirty shed upon stale litter, where perhaps the matter has already fallen from a previous subject. Poulticing and the application of mild liniments promote suppuration and curtail the illness. Scalded foods, bran and linseed mashes, sliced carrots, and other easily prehended and masticated food should be provided. Iron and gentian as tonics are recommended in the convalescent stages. [H. L.]

Strath.—This term is used in Scotland for a broad valley, and with special reference to its floor, in which alluvial deposits will generally be conspicuous. In the mountainous districts, the strath forms the natural highway and means of communication, and supports, by its agricultural possibilities, almost the entire population. Strathearn is a typical example of a rich alluvial valley in the foothills of the Highland border. [G. A. J. C.]

Stratigraphy. See art. GEOLOGY.

Straw.—Crops that are primarily grown for the seed they produce are commonly referred to as 'straw crops', the term 'straw' being

applied to the air-dried stems and leaves from which the seed is separated by threshing operations.

The common straws may be classified into cereal straws (wheat, rye, barley, oat straw) and leguminous straws (bean, pea straw). These straws are mainly utilized either as food for cattle or as litter. The nutritive value of straw is usually low, but depends largely upon the degree of ripeness of the crop when harvested. From the time that seed formation commences there is a steady transference of nutritive materials from the stems and leaves of the plants to the seed, accompanied by a rapid lignification of the stems. Hence the more completely the seed is allowed to ripen, the more thoroughly will the straw be exhausted of the most valuable nutritive matters, and the harder and more difficult to masticate will it become. The nutritive value of straw is determined very largely by its content of digestible carbohydrates and fibre, and by its hardness or toughness. The albuminoid content is always low, ranging from about 3 per cent in the cereal straws to 8 or 9 per cent in the leguminous straws, little more than one-third of these amounts being digestible true albuminoid. The upper portions of the stems are usually appreciably more nutritious than the lower portions. Moreover, any conditions that tend to hamper seed formation, *e.g.* drought, 'laying' of crop, &c., will leave the straw richer in digestible nutrients than under normal conditions. Manuring has but little influence upon the nutritive value of straw.

The cereal straws rank as foods amongst the poorest in albuminoids, and richest in crude fibre. In general, the lower the content of crude fibre the more nutritious will the straw be. This largely explains the superiority of the straw of the rapidly-grown summer cereals (oats, barley) over that of the winter-sown cereal crops (wheat, rye), or the straw of spring-sown oats over that of winter-sown oats.

The leguminous straws are appreciably more nutritious than the cereal straws, being richer in albuminoids and less burdened with crude fibre. Bean and pea straw of the best quality are fully equal in feeding value to good meadow hay or medium clover hay. They are liable to deterioration by fungoid attacks, however, and difficult to harvest in the best condition. They also require greater caution in their use. (For detailed information of the different straws, see FODDER, BARLEY PRODUCTS, BEAN STRAW, &c.)

Repeated attempts have been made to convert straw into a softer and more digestible condition by heating with soda lye under pressure, whereby the straw is reduced to a soft, more or less pulped condition. The nutritive value of the straw is greatly increased by this treatment, but the cost of production is at present too high to admit of any extended commercial application.

The use of straw as litter for farm animals is universal. Wheat straw is commonly regarded as the cleanest and most suitable for this purpose, barley straw being softer in texture, and often brittle and dusty. Moreover, oat straw (often barley straw) and the leguminous straws can usually be more profitably utilized as food. For further details, see LITTER.

The amounts of straw that are used for purposes other than the above are comparatively small. Reference may be made to the occasional use of straw in paper-making; the straw-plait industry, for which special varieties of straw are cultivated in some districts; and such minor uses as the filling of cheap mattresses and the packing of fragile goods. [C. C.]

Strawberry.—The garden strawberries are probably derived from three species of Fragaria (nat. ord. Rosaceæ)—*F. vesca* (a native plant), *F. chiloensis* (South America), and *F. virginiana* (North America); and there are three races of them—the English or large-fruited (by far the most important in this country), the Alpine, and the so-called Perpetual-fruiting. It might well be supposed that the name Strawberry arose from the practice of laying down straw among the plants; but this is not so. It is undoubtedly a corruption of strayberry, this name having reference to the manner in which the plants throw out runners, and thus tend to 'stray' from the garden back to the woods. It is not known precisely when strawberries were first cultivated, but it was not until the Middle Ages; and the large-fruited kinds do not date back more than 150 years, while it was not until the early part of the 19th century that varieties approaching in excellence those of to-day were produced. Numerous fine new sorts continue to appear, but there is a tendency to breed for size and appearance of fruit rather than for firmness of flesh and superior flavour.

GARDEN CULTIVATION.—Strawberries will grow in any fairly good soil, but a rich sandy loam, which does not, however, readily dry up, is the best. Heavy soils are not suitable for strawberry cultivation on a considerable scale unless specially treated, and very wet land is not good. It is preferable to trench the soil, and it should be liberally enriched with manure. Summer planting is the best, using the earliest runners; but where this is not possible, early autumn will do. Again, runners out of pots or from a nursery bed may be planted in February or March. The planting distance is very variable, depending on the length of time it is proposed to leave the plants in the beds, the vigour of the variety, and on individual taste. For example, 2½ ft. apart each way is not too much for plants of Royal Sovereign; but some growers plant only 18 in. apart, leaving a wider alley, say, after every third row; or the plants may be put in closely at first, and every other one removed after the first crop of fruit. It is not uncommon to see strawberry beds in gardens, which are five, or eight, or even more, years old. This is a great mistake. Personally we should make a fresh bed on a different site after the third year, while there are growers who favour the plan of allowing early varieties to produce only one crop. Another prevalent error is to permit the beds to become choked up with runners, whereas all those which are not required for propagation should be cleared off soon after they appear. Some growers mow down the old foliage with a scythe; but while it is well to

remove it, this should be done carefully so as not to injure the new crop of leaves. We favour the practice of mulching in spring with long stable litter, first applying a dressing of lime to check insect pest. The litter will be washed clean by the time the fruits swell, and will then serve the purpose of that dressing with clean straw which is essential to preserve them from being spoilt by heavy rains. Weeds must be constantly kept down, and it is labour well repaid to water copiously and repeatedly should the weather be dry when the plants are swelling their fruit. Do not dig deeply among strawberries, but surface stirring of the soil is beneficial. Should a very large number of blossoms successfully set, it is a good plan to remove some of them so as to encourage the bearing of fine large berries only; the lowest blossoms produce the earliest and finest fruit. We recommend the culture of early, mid-season, and late varieties to provide fruit over as long a season as is possible. Where strawberries are grown on a small scale it is often necessary to net them to keep off the birds.

Varieties.—These are very numerous, a great number of them being inferior and obsolete, and there is rarely occasion to go beyond the following small selection: Royal Sovereign, an excellent all-round variety; King of the Earlies; Noble, early and a good cropper, but inferior in colour and in flavour; Sir Joseph Paxton, an old sort, but firm of flesh, of fine flavour, and splendid for travelling; The Laxton, considered by its raisers to be superior to Royal Sovereign; Bedford Champion; British Queen, unsurpassed for flavour, but does not do well in all localities; Givon's Late Prolific; and Latest of All.

Strawberry Forcing.—This is a considerable industry, particularly so on the South coast, though prices have declined somewhat of late years; and in private gardens containing a fair amount of glass a few strawberries should certainly be forced. The finest and earliest runners are selected from plants which have not been allowed to fruit, and are rooted in good soil in 3-in. pots, being subsequently transferred singly into 5-in. or 6-in. pots, in a compost of good turfy loam with some leaf mould or well-rotted cow manure. They are kept growing vigorously throughout the summer, and on the approach of winter are turned on their sides to keep out excessive moisture, or else placed in a frame. They are taken into a heated greenhouse from December onwards as required, being placed as near the glass as possible, and stood in saucers or on turves, the finest plants being picked out for the earliest batches. The temperature should not exceed 45° to 50° F. at first, and it must be moderate until the berries are set, when it may reach 75° with sun heat. It is well to keep the plants a little drier at the roots than usual when they are flowering, and they should be fed when the berries commence to swell. An extra early crop is the most profitable, but in private gardens a succession of fruit until that from outside comes in is more to be desired. Royal Sovereign is an excellent variety for forcing. Vicomtesse H. de Thury and Keens' Seedling are also forced. Mildew and Red Spider may prove troublesome under glass.

Alpine Strawberries.—These are of good flavour, but are as yet but little grown in Great Britain. Continental growers usually raise them from seeds, treating them as annuals and biennials. Belle de Meaux, Bergen, Janus, Blanc, and Rouge Amélioré are the most popular varieties.

Perpetual Strawberries.—These, which are crosses between the English and the Alpine Strawberry, also have but little vogue in this country; but this is largely because wrong methods of cultivation have been adopted, and they are now increasing somewhat in popularity. It requires to be understood that the best successional crops of fruit are not produced upon the old stools, but on the first and second runners of the current season. Thus runners should be encouraged as much as possible, and plenty of room left for their pegging down. Some runners may be layered in pots and taken indoors for autumn fruiting. Jeanne D'Arc, S. Anthonie de Padoue, St. Joseph, Oregon, and Louis Gauthier are the best kinds. [W. W.]

FIELD CULTIVATION.—Of late years the field cultivation of strawberries has become an important industry in many parts of the country, more especially in the counties of Kent and Hampshire, and on the banks of the Clyde in Scotland; the soil and climate of these districts appear to be naturally favourable to the crop. Strawberries as cultivated in the open fields are an uncertain crop: in some seasons it may prove to be highly remunerative, in others the margin of profit may be very slight. The finest blooms may be completely destroyed by late spring frosts, or a wet fruiting season will injure the quality and keeping power, and considerably reduce the market value of the fruit.

Cost of Cultivation.—The cost of renting suitable land for strawberry growing may amount to anything from £2 up to £5 per acre; the breaking up and planting of new ground will cost from £20 to £30 per acre; while bastard trenching old plantations will often cost more than £10 per acre. Much of the land under strawberry cultivation is ploughed to a depth of from 12 to 15 in. at a cost of from 15*s.* to 30*s.* per acre.

The strawberry grower's year of preparation commences in October, when he has to prepare the ground for the runners, the soil having been first summer-fallowed. In garden cultivation it is customary to plant specially layered runners in July, but with the majority of growers little planting is done before October, when the work is often continued into May. A heavy coating of manure is the first essential, and anything from 30 to 40 tons of dung or manure is applied per acre; the average cost of this manure delivered on the farm and applied to the field may be from 7*s.* 6*d.* to 8*s.* 6*d.* per ton, while the cost of spreading may be estimated at from 2*s.* to 2*s.* 6*d.* per acre. The price of runners varies according to variety, and whether they are specially layered plants or merely self-rooted runners which have received no special preparation before lifting: the former

will cost from 10s. to 15s. per 1000, while the latter are plentiful at 5s. per 1000. The number of runners required to plant an acre can be estimated at from 12,500 to 16,000 to the acre, which numbers allow for weaklings being planted two together. If planted 2 ft. apart, close upon 11,000 are required; but the distances between the rows vary considerably, and, in some cases, rows 30 in. apart and 12 to 15 in. from plant to plant are common. Varieties like 'Paxtons' and 'Nobles' are often planted 2 ft. from row to row and 1 ft. from plant to plant; thus nearly 20,000 plants would be required to plant 1 ac. Planting is usually performed by piece work, and may cost from 15s. to £1 per acre for dibbling in the runners.

After Cultivation.—A considerable amount of labour is necessary from the time of planting until the fruit is ready for gathering, hand and horse hoeing being much in evidence. The plants must also be gone over four or five times for the purpose of removing runners, which work will add about 12s. to the expenses of cultivation. The total cost of hoeing on average land, including three hand hoeings, each of which will cost about £3, would be approximately £12, estimating the period covered as twenty months from the time of planting to the gathering of the first batch of marketable fruit. Steam-baled barley straw has now almost superseded the older and less hygienic method of bedding down the plants previous to flowering with short manure; the amount of straw required varies from 15 cwt. to 1 ton per acre, and will cost from 8s. to 10s. per acre for laying or bedding between the plants. On heavy soils, plantations may continue to give profitable returns for five years, while on lighter soils they cannot prove profitable beyond the third year.

Gathering and Marketing.—An average yield per acre of strawberries may be estimated at 1000 baskets, each containing from 4 to 5 lb. of fruit; in exceptional seasons as many as 2000 baskets have been secured from 1 ac. of ground. The very early consignments bring fancy prices, but the general price in a good season does not average more than 1s. 3*d.* for a 5-lb. basket, while in a bad season it may be nearer 10*d.* (or 2*d.* per lb.). The cost of gathering the fruit varies from ¼*d.* to ½*d.* per lb., or an average of 1½*d.* per gal., to which must be added the cost of baskets and haulage to rail, railway freights, salesmen's fees, &c., the total cost of which may amount to anything between £12 and £20 per acre. The 'chip' baskets are now almost exclusively used instead of the wicker basket; the great advantage possessed by the former is their comparative cheapness—they can be purchased at 1*d.* each in 50-gross lots—and they are non-returnable.

In good seasons, as much as £50 may represent the return from 1 ac., and in exceptional seasons £100 is reached, while in bad seasons it may fall as low as £20.

The principal varieties of strawberries for market are: Royal Sovereign, Sir Joseph Paxton, President, Noble, Bedford Champion, Kentish Favourite, and Givon's Late Prolific. There are other varieties, each suited for certain classes of soils and districts, and these several characteristics must be taken notice of when a selection is being made. [J. C. N.]

Strawberry. — Parasitic Fungi. — Damage to foliage generally takes the form of yellowish spots with a reddish-purple margin (fig. 1); when the spots are numerous and run together, the leaves wither completely. The fungus present is *Sphærella fragariæ*, which, after producing numerous summer spores, passes the winter either in the form of winter ascus-fruits or as fungus-filaments in the dead leaves. As the disease begins to injure the plants early and continues active till late autumn, serious damage may be done as regards cropping next season. Some varieties are more liable to attack than others.

Strawberry-leaf Spot

Treatment. — Weak Bordeaux mixture (see FUNGICIDES) should be sprayed as soon as the disease is seen; another spraying may be given later, but not after the fruit has set. To destroy the dead leaves, after collecting the crop, scatter a thin layer of straw over the bed and set it on fire, care being taken not to use much straw, as excessive heat injures the crowns.

Powdery Mildew first occurs on the leaves, but is easily overlooked till the white mouldy coating appears on the fruit, where much damage may result. The fungus (*Sphærotheca castagnei*) also produces mildew on hops, and the disease may pass from one crop to the other.

Treatment.—Mildew will be checked by the methods recommended above for leaf-spot. Flowers of sulphur alone or mixed with half its weight of quicklime, and dusted carefully beneath the leaves, is also a useful remedy, but must not be applied to fruit.

Fruit rot accompanied by a greyish fungus (*Botrytis*) is sometimes destructive, especially in wet seasons when the fruit ripens slowly; nothing except sunshine is likely to do much good. [W. G. S.]

Strawberry, Insect Enemies of.— The following is a list of the chief insect pests of the strawberry: *Hepialus lupulinus* (Garden Swift Moth), *Agrotis exclamationis* (Heart-and-Dart Moth), *Melolontha vulgaris* (Cockchafer), *Galerucella tenella* (Strawberry-leaf Beetle), *Otiorhynchus sulcatus* (Strawberry Weevil), *Anthonomus rubi* (Strawberry Anthonomus), *Adrastus limbatus* (Strawberry Click Beetle),

These various insects are described under their technical designations.

Strawsonizer, a machine extensively used for spraying of chemicals to destroy weeds and to prevent insect and fungoid attacks. See SPRAYERS.

Strength of Materials. See art. MATERIALS, STRENGTH AND ELASTICITY OF.

Stringhalt.—An ill-defined affection of the nervous system characterized by a spasmodic clicking up of one or both hind legs. This defect is classed among the nervous affections, and has the appearance of being due to exalted function of the nerves which govern the flexors of the hind limb, but the most careful post-mortem examinations have failed to discover any lesions or anything abnormal whatever. Many theories have been advanced and a variety of treatments adopted, but with very little success. The malady may suddenly declare itself in a pronounced form, or may slowly and insidiously increase. The heavy breeds are no more exempt than the light ones, but horses whose work does not call for trotting or fast paces are less able to throw off the jerking movement with exercise. As the disease invariably increases as time goes on, it is important to recognize early symptoms and avoid purchasing, as sound, an animal with any inclination to stringhalt. We have said that it invariably increases, but this must be qualified by the statement that there are periods of partial remission, and even of apparent temporary cure, when horses are turned out to grass; but when taken in again, it reappears. Advantage is often taken of this diminution of the symptoms outdoors to sell to the unwary while in the field. When the spasmodic action of the limb increases to a very great extent, the subject of it loses condition and becomes more or less tucked up in the flank, as horses do with any kind of lameness or cause of pain in a hind limb. Animals are to be seen occasionally with such an exaggerated form of stringhalt that they actually strike the belly with the foot. One or both legs may be involved, but seldom in equal degree, so that the subject often appears to have but one limb affected when both are influenced. Stringhalt should teach us the advisability of seeing a horse in the stable and cooled down before committing ourselves to a purchase. It is one of several maladies that display themselves when the animal is made to stand over across the stall. If the subject of this defect he will snatch up the affected limb, and should certainly be made to pass to both sides of the stall. Spavin and navicular disease (which see) are best looked for when a horse has been stabled long enough to cool down. This disease is hereditary, and horses affected with it should not be used for stud purposes. [H. L.]

Strippings consist of the last-drawn milk from a cow at any milking. They are characterized by being much richer in fat than the average milk yielded by the cow, often containing over 10 per cent of this ingredient. The first-drawn milk or 'fore milk' is very poor in fat, the quantity of this constituent rising as the process of milking proceeds, and being much richer in the last ½ pt. which can be stripped from the cow. The following example is typical of the results obtained in hundreds of cases with the milk of Shorthorn cows at the Midland Agricultural and Dairy College.

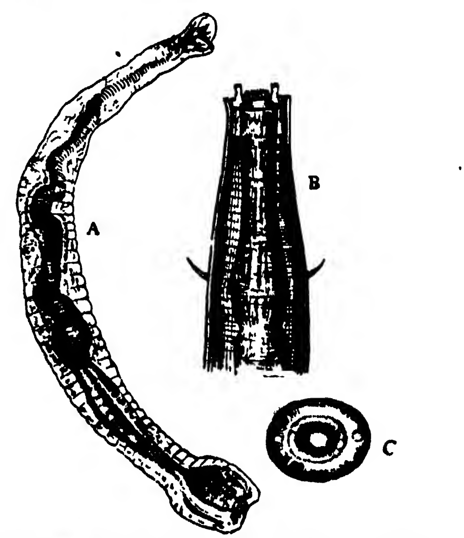
Three 6-oz. bottles were taken to the cow shed at 7 a.m. No 1 was filled direct from the cow with the first-drawn or fore milk. The milking was then proceeded with, and when the cow had yielded about half the quantity which was expected, bottle No. 2 was filled. Bottle No. 3 was filled with the strippings. The same cow's milk was again sampled in the evening at 5 p.m. in the same manner. The percentage of fat was determined in the milk in each bottle, and gave the following results:—

	7 a.m	5 p.m.
No. 1, fore milk ..	0·4 % fat.	0·8 % fat.
No. 2, middle milk ...	2·0 ,,	3·2 ,,
No. 3, strippings ...	12·2 ,,	8·0 ,,

The strippings are found to be richer in fat after a longer period has elapsed between milkings than after a shorter period. The other constituents of the milk do not vary to anything like the same extent.

It is of the greatest practical importance that the cows should be well milked and well stripped. It may even happen that an inefficient milker may not only get less milk, but that the milk so obtained may fall below the standard required by law, while the few extra pounds obtained by a skilled milker will bring the milk above the standard.

In taking samples of milk from individual cows, all the milk from the cow must be milked into a pail and then well mixed before the bottles are filled. [J. Go.]

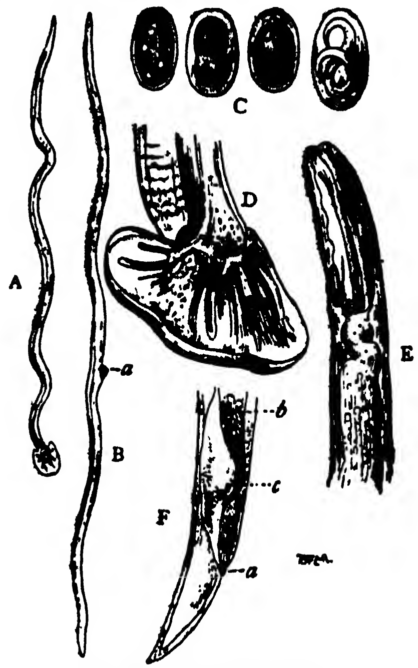


A, Strongylus tetracanthus, male, magnified B, Anterior extremity, dorsal view C, End view of anterior extremity.

Strongylosis.—This term is applied to disease caused by worms belonging to the genus

Strongylus. It is, unfortunately, on the increase in these islands, and none of the domesticated animals are wholly exempt. The cough known as husk in calves and lambs is a verminous bronchitis or strongylosis induced by *S. micrurus* and *S. filaria*, and a fatal scour is often set up by *S. contortus* in the fourth stomach. *S. tetracanthus* is one of the worst enemies of the horse-breeder. The chief symptoms of the disease caused by this worm are wasting and diarrhœa accompanied by a dull abdominal pain. In colts at grass, *S. tetracanthus* may destroy its victims without for a time producing other marked symptoms than those of anæmia. Wandering strongles of different kinds are found in animals without causing what is here intended as strongylosis, but they have special periods of activity and of multiplication, when they produce serious disease and actual death. Rock salt broken up and spread over the land at the rate of half a ton to the acre has been found of great value in keeping down strongles. When the particular strongle has been identified, as, for instance, when the *tetracanthus* has made horse-breeding unprofitable, the land may be stocked with bovines or with sheep until the horse strongle has been starved out; and the process may be reversed when verminous bronchitis caused by strongles has afflicted calves and lambs. See art. STRONGYLUS. [H. L.]

Strongylus, an important genus of Nematode worms, found for the most part in mammals, but also in birds and reptiles. The mouth is surrounded by six small papillæ; the posterior end of the male shows a prominent lobed copulatory pouch (or bursa) with two spicules; the posterior end of the female is pointed. Infection seems to be direct and without the aid of an intermediate host; the larvæ occur in damp earth and in foul water, and are thus readily swallowed along with the food or drink. There are numerous species of Strongylus, which occur in various parts of the body, such as the intestine, the lungs, the trachea, the large blood-vessels. The armed palisade worm (*Strongylus armatus*), a reddish-brown species about 1 in. to 2 in. in length, occurs in the intestine of the horse and the donkey. The eggs, passed out with the dung, hatch in damp places, and the larvæ may be swallowed with the drinking water. They pass from the gut to the walls of adjacent arteries, sometimes causing serious aneurisms. As they mature they pass into the blood-stream, and thence, by boring, into the intestine. The sheep strongyle (*S. contortus*)—male ½, female ¾ in.—often occurs in great numbers in the abomasum or reed. The lung-worm of lambs (*S. filaria*)—male 1 in., female 3 in.—infects the lambs in summer, passes from the stomach to the windpipe, remains embedded in swellings till spring, when numerous young forms are liberated into mucus of the windpipe. Often, however, the host dies long before this. A small species, *S. micrurus*, occurs in the windpipe and arteries of cattle; another, *S. apri*, lives in the bronchial tubes of the pig, and is also found occasionally in sheep and man. Both these species cause bronchitis, which is often fatal in calves and young pigs. The giant palisade worm, which occurs in the cavity of the kidney (and sometimes in the abdominal cavity) in horses, cattle, deer, dog, man, &c., belongs to a nearly related genus, Eustrongylus. It is a very serious parasite, and well deserves its name of *gigas*, for the male may be over 1 ft.



Lung-worm (*Strongylus filaria*)

A, Male. B, Female (*a*, anus). C, Ovum in various stages of development. D, Caudal pouch of male, profile view. E, Anterior extremity, showing œsophagus. F, Enlarged extremity of ♀ (*a*, anus; *b*, uterus; *c*, intestine).

long and the female over 1 yd. It causes kidney disease and grave disorders. [J. A. T.]

Strophosoma coryli.—This is a weevil about ¼ in. long, short and thick. Both adult beetles and larvæ are injurious; the former eat the needles and bark of young conifers and broad-leaved trees, and the larvæ feed on young roots, but the adults do most harm. The beetles pair in June, and oviposit on the small rootlets near the surface of the soil, especially in dry places. They are very similar to other Cuculid larvæ, being footless and white. In the beginning of August they pupate near the surface, and at the end of the same month and on into September the beetles hatch out. They are wingless, and hibernate. In spring they crawl up the trunks of the trees and feed as described, preferring young trees.

Protective rules given by Schlich are as follows: Grubbing up of all stumps and root stocks; the employment of well-grown and not too young plants; trap ditches to catch the crawling beetles; the collection of beetles in August and September under pieces of bark on the ground; collection of the beetles by shaking in spring. [F. V. T.]

Stump Extractors are machines of various sorts, which all work upon the principle of gaining great force by leverage. If the side-roots have been cut through all round, the stump can often be raised by the leverage of a long and stout pole passing through an iron ring attached to a strong hook, that can be inserted below one of the main side-roots. Or a long

Fig. 1.—Grubbing Stump with 'Monkey' Jack

pole can be fixed with one end resting on the ground and the other on the top of a jack, with an iron chain binding this end of the pole to one of the stump-roots; and as the jack is wound up, the stump is partially tilted over. The Australian monkey jack is another method of applying strong leverage. One of the most powerful stump extractors is the American 'Hawkeye' machine, worked by horse-power,

Fig. 2.—Grubbing Stump with 'Monkey' Jack

the machine itself being firmly moored to one or more stumps, as necessary for stability, and the extracting force being provided by strong leverage. Large stumps are also often blasted with gunpowder or dynamite, but this is not always cheaper than the use of mechanical appliances. Stump extraction is only profitable where there is a good market for fuel, but it is the best safeguard against the Pine Weevil. [J. N.]

Styptics, substances which arrest hæmorrhage when locally applied. They are nearly akin to astringents, which cause constriction or contraction of the tissues either by topical application or through the circulation of the blood. A constringing drug given by the mouth, and intended to act locally upon the injured mucous membrane of the bowel, would be considered an astringent, although operating in much the same manner as a styptic immediately applied. Nut galls in powder, tannic and gallic acid, oak and elm barks, catechu, kino, alum, iron, copper, zinc, silver, chalk and bismuth, are substances employed both as styptics and astringents. Gallic acid is given as an internal styptic or astringent to arrest hæmorrhage where mechanical means cannot be employed; so also is lead acetate; and for ulcerating surfaces, disposed to bleed, in stomach and bowels, the salts of silver and copper and iron are prescribed. For the general means of arresting bleeding, and the practical application of styptics, the reader is referred to the art. BLEEDING. [H. L.]

Subcoccinella 24-punctata (the Leaf-feeding Ladybird).—Most Ladybird beetles are beneficial on account of their carnivorous habits, but the present species is injurious on account of its vegetarian proclivities. The plant-feeding Ladybirds can at once be told by the wing cases being pubescent; many of them are very harmful abroad (Epilachnas), but this is the only one found in Britain. In size it is about ⅛ in. long; it is almost hemispherical, clothed with thick greyish pubescence, of a reddish or ferruginous colour, with black spots on the thorax and elytra; the legs and antennæ are reddish. The beetles and larvæ feed upon clovers, tares, lucerne, vetches, &c., eating away the parenchyma of the leaves. The larvæ are yellowish, of somewhat elliptical shape, and more or less spinose, with a few dark markings, the last segment having a nipple-like anal process. They feed with the adults on the same plants and pupate on the leaves. [F. V. T.]

Subsoil.—This term is applied to the soil lying below the top 6 or 9 in. It represents more nearly the original soil, since it is unaffected by cultivation or manuring of the surface soil. Some of the plots at Rothamsted have for over fifty years received 3½ cwt. of superphosphates each year — a total now of nearly 8 tons; yet the subsoil below 9 in. is no richer in available phosphoric acid than that of the plot unmanured since 1839. The dunged plots have been receiving 14 tons annually, *i.e.* 700 tons during the whole period, but the subsoil is little, if any, richer in nitrogen or organic matter. The explanation is, that soil has an extraordinary power of precipitating soluble substances from their solutions: organic matter, ammonia, phosphoric acid, and potash are all held by the particles near the surface, and get no further than the cultivation operations will take them.

But during the long period that has elapsed since the soil was formed, the rain has been perpetually washing some of the clay particles downwards. Thus we always find more clay in the second 9 in. than in the surface soil. Further, the clay in the subsoil has not been subjected to the flocculating influence of cultivation, organic matter, lime, &c., and is therefore in a much less workable condition than that of the surface. Hence the sticky, unkindly

nature of the subsoil. Chemically, the subsoil contains less organic matter (hence its difference in colour), less nitrogen, but more potash than the surface soil; both contain about the same amounts of phosphoric acid. The subsoil compounds, however, are much less soluble and 'available' than those in the surface soil. It is now known that the old idea is wrong which supposed the subsoil to be the reservoir of plant food from which the surface soil drew its supply. The subsoil is much *poorer* in plant food than the surface, and there is no advantage, but distinct disadvantages, in bringing it to the surface. The micro-organic flora of the subsoil is simpler than that of the surface. The number of organisms is smaller, and only those survive that are capable of doing without much air.

These differences are, however, much less marked in dry regions, and thus it happens that in levelling land for irrigation a scoop can be sent over it to pick up the soil in the raised parts and transfer it to the hollows. The laying bare of the subsoil leads to no long period of sterility as would be the case here.

While the subsoil is heavier than the surface if the two have the same geological origin, it may be much lighter if they are geologically distinct. Thus clay may wash on to sand and give rise to a heavy surface soil lying on a light subsoil. It may wash or be deposited on to chalk, as in the belt of country round London, in which case it is a distinct advantage to bring up some of the chalk subsoil to the surface and use it as a manure. This indeed was until about a hundred years ago the recognized treatment of these soils.

In spite of its general unkindliness the subsoil is penetrated by the roots of certain plants —wheat, mangolds, Red Clover, Lucerne, Sainfoin among ordinary crops, and by many pasture plants; and this tendency is, in pasture land, fostered by the use of manures like nitrate of soda, that wash down into the soil. The only practicable method of improving the subsoil on farms, apart from drainage, is to grow deep-rooting crops, which open the subsoil, increase its stores of organic matter, and effect a certain transference of plant food to the surface. Various systems of land improvement have been based on this plan. Sainfoin and Lucerne have the advantage of being leguminous plants and therefore increasing the nitrogen supply of the soil, but Chicory and other plants have been found useful.

One great advantage of improving the subsoil is that the root range of the plant, and consequently the water supply, is increased. Indeed it is largely in relation to the water supply that the subsoil is important. The best results are obtained when the subsoil is sufficiently compact to hold back enough water, without, however, allowing it to accumulate and stagnate. On the other hand, very porous subsoil leads to overdrainage and consequently infertility, which cannot be altogether remedied. When the surface soil is underlain by solid rock, the conditions may be favourable both to root development and water supply if the rock is vertical, especially if it is soft enough to be split by the roots; but they are usually unfavourable if the rock is horizontal. [E. J. R.]

Subsoiling, or **Subsoil Ploughing,** is actually a scarifying or knifing of the subsoil by a tine or coulter let down from the frame of a strong plough constructed specially for the purpose. Or the subsoiler may be attached to the frame of a steam plough. If it takes the form of a separate implement it is furnished with a beam, frame, and stilts like an ordinary plough, but is destitute of mould-board or true land-side; and the coulter is produced downwards and terminates in a strong tine which is drawn through the ground at the bottom of a newly turned furrow. In this case it is preceded by a strong plough, drawn by four horses, which turns out a deep 9-in. furrow. The subsoil plough, also drawn by four horses, follows, and the work performed at each turn is covered up by the next furrow. The principle of subsoiling is pulverization without bringing the subsoil to the surface, and in this respect it differs from trench ploughing (see TRENCH PLOUGHING). Subsoiling is especially suitable for steam power, and all that is necessary is a coulter or knife so fixed behind each turn-furrow as to enter and pulverize the subsoil to a depth of 7 to 9 in. below the bottom of the furrow. It is not adapted for solid and retentive clays, as might naturally have been expected. Such soils close in a short time through their natural plasticity, so that all traces of the operation are soon obliterated. The best results have been obtained upon subsoils of a shelly or calcareous nature, which offer a barrier to the downward passage of water, and form a definite or indefinite 'pan', a few inches below the surface. It is also the best means of dealing with muir-band pan, an ochreous ferruginous deposit, often found under heaths. These pans, when once broken up, never form again, and hence the operation of subsoiling is a permanent improvement followed with excellent results.

Subsoiling has often been regarded as a critical operation involving possible injury to the ground, and to the productive powers of the soil. In this respect, however, it is not so fraught with danger as is trench ploughing, because there is no mixing of poor or sour subsoil with a well aerated and manured surface soil; but only a breaking up of the pan whether of muir-band, calcareous deposit, or a mere indurated pan, produced by the continuous treading of horses for a long series of years. [J. WR.]

Subsoil Plough. See PLOUGH.

Succession, Intestate.—

1. ENGLAND

(a) *Real Property.*—The order of descent of real estate on the death of the owner intestate is governed by Statute, the main rules whereof are as follows, viz.: The descent is in every case to be traced from the purchaser, *i.e.* the person who last succeeded otherwise than by descent. The estate descends lineally to the issue of the purchaser so long as there is any, males being preferred to females, and an elder male to a younger. In the case of females, however, they take jointly and are known as coparceners, so

called because they are entitled to demand a partition by the Court, failing a voluntary agreement. In the event of no partition, however, the interest of a coparcener descends to her children, if any. The issue of children of the purchaser represent their parents; thus, if the eldest son of the purchaser predeceased leaving children, male or female, they would take in preference to the second son of the purchaser. On failure of lineal descendants the property passes to the nearest living ancestor; thus the father of the purchaser will succeed before the brothers or sisters. In the case of ascendants the male line is preferred to the female line. On the failure of a lineal ascendant his issue, if any, succeed; thus, on the predecease of the father of the purchaser leaving a family the property will go to them, as in the first instance to a younger brother of the purchaser and his family, or in the case of sisters to them as coparceners. The full blood excludes the half; that is to say, a full brother will succeed before any of the issue of the father's marriage with the second wife can succeed. After the ascendants in the paternal line and their issue are exhausted, the property passes into the maternal line. Lastly, if there is a total failure of heirs of the purchaser, the descent is traced from the person last entitled to the lands as if he had been the purchaser thereof.

(b) *Personal Estate.*—The distribution of the personal estate of an intestate after payment of debts is regulated by the Statute of Distributions, which provides as follows, viz.: The husband of the deceased is entitled to the whole estate left by his deceased wife, while a widow is entitled to one-third if there be a family or other lineal descendants, otherwise to one-half. If, however, a man die without issue and his whole estate, real or personal, does not exceed £500 net, the widow is entitled to the whole of it; and if it exceed £500, then she is entitled to a sum of £500 in addition to her share of the personal estate. The children are entitled to two-thirds of their father's estate if he is survived by a widow, otherwise to the whole. The representatives of a child who has predeceased take the share which he or she would have been entitled to on survivance. Failing issue, the next of kin take one-half if a widow survive, and the whole if there is none. No representation—*i.e.* the taking of children in place of their parents—is admitted among collaterals beyond the children of brothers and sisters of the intestate. The next of kin are ascertained by counting from the intestate back to the common ancestor, and thereafter down to the parties claiming to succeed, each step counting a degree; but brothers and sisters of the deceased are entitled to take in preference to the grandfather, although they are both in the same degree of relationship. The father of the deceased excludes the mother. On failure of the father, the mother succeeds along with the brothers and sisters of the deceased, and the issue of any deceased brother or sister.

2. Scotland

(a) *Heritage.*—On the death of a person intestate, the heritable estate descends to the eldest son and his issue, male and female, until the line is exhausted, males succeeding before females. On failure of the eldest son and his issue if any, the second son and his issue take, and so on till all the male issue are exhausted. Thereafter the daughters, if more than one, take the property between them *pro indiviso* as heirs portioners, the issue of a daughter who has predeceased taking their mother's share, the male issue having a preference. The eldest heir portioner has a right to the mansion house of an estate in the country, but has no such right to a town house or to a villa though in the country. She is also entitled to such dignities and titles of honour as are not otherwise limited, without making any compensation to her sisters therefor. She is also entitled to the property of things indivisible, but subject to compensation to her sisters. On the failure of descendants, the succession to the heritable estate goes out to the collateral line. The next younger brother and his issue succeeding to the immediately elder brother, and so on from elder to younger till all the younger brothers and their issue are exhausted. Thereafter the elder brothers and their issue succeed in the inverse order, *i.e.* the immediately elder first, and thereafter upward to the eldest. After the failure of brothers and their issue, the sisters succeed as heir portioners. In the succession of collaterals the full blood excludes the half; but on the failure of the full blood the half blood *consanguinean* (*i.e.* descendants of the same father but not the same mother as the full blood) will succeed, males taking the preference as in the case of the full blood. The half blood *uterine* (*i.e.* descendants of the same mother but not the same father as the full blood) is entirely excluded. After failure of collaterals, the heritage ascends to the father and his relations to the exclusion of the mother and her relations, to whom it never ascends.

Husband and wife never succeed to each other, but they have the following rights in the estate of an intestate. The husband, if the father of the heir at law, is entitled to a liferent of the heritage, known as his courtesy. If no child has been born of the marriage, the husband is not entitled to the right of courtesy. The wife, unless barred by provision, is entitled to a liferent of one-third of the heritage, known as *terce*, whether there be children of the marriage or not.

(b) *Moveables.*—In the case of a husband dying intestate, the deceased's moveable estate, if he left a widow and family, is divisible into three parts: one part whereof, known as the *jus relictæ*, goes to the widow; one part, known as *legitim*, goes to the children equally among them; and the third part, known as the *dead's part*, will go to the children as the next of kin. If he leave a widow but no children, the *jus relictæ* will amount to one-half of the moveable estate; and if he leave a child or children but no widow, the *legitim* will amount to one-half, the remainder in each case being the *dead's part*. On the death of a woman survived by a husband, he is entitled to the same rights in her estate as a wife is in that of her deceased husband. On the death of a person predeceased by husband or wife, as the case may be, and without issue, the whole

moveable estate is *dead's part*. Even if the deceased has left a will, he or she is only entitled by law to deal with the *dead's part*; and the widow (or widower) and family are entitled to claim their legal rights, if they prefer them to the rights given under the will, except in so far as these rights have been renounced or excluded. The issue of a child or of any descendant of a child who has predeceased the intestate comes in place of his parent, and has right to the share of the moveable estate other than *legitim* to which his parent, if he had survived, would have been entitled; but no representation is admitted among collaterals beyond the descendants of brothers and sisters.

Where the heir by virtue of *primogeniture* takes the heritage, he is not entitled to insist on a share of the moveables as well as the next of kin, except on condition of collating, *i.e.* massing the heritage with the moveables so as to form one joint fund; in which case he is entitled to an equal share of the aggregate amount.

On the failure of descendants the next of kin are found among the collaterals, *i.e.* the brothers and sisters of the deceased and their descendants, subject to the rights of the father or mother of the deceased, if alive, to a share in the estate, which are as follows: In the case of a person dying intestate without issue, his father, if alive, has a right to one-half, and failing the father, the mother, if alive, has a right to one-third of the *dead's part* in preference to the brothers or sisters or their descendants. Where an intestate dies without leaving issue, and his father and mother have both predeceased, and leaving no brother or sister german (*i.e.* full) or *consanguinean*, nor any descendant of a brother or sister *german* or *consanguinean*, but leaving brothers and sisters *uterine* or their descendants, such brothers and sisters *uterine* and their descendants in place of their predeceasing parent are entitled to one-half of the moveable estate left by the intestate.

Death Duties. — Property passing on the death of a person, either under his will or on his intestacy, is liable in payment of estate duty, and in some cases also of legacy and succession duties.

1. *Estate Duty.*—This duty is payable on the principal value of all property, heritable or moveable. The property includes any of which the deceased was competent to dispose at his death whether he did so or not. It also includes donations *mortis causâ* and gifts of property made by the deceased within three years of his death without reservation, or gifts made at any time with any reservation to the deceased. Life interests, annuities, &c., are all chargeable. For determining the rate of estate duty, all property in respect of which the duty is leviable is to be aggregated so as to form one estate, and the duty is levied on the principal value thereof. Where the net value of the property on which estate duty is payable (exclusive of property settled otherwise than by the will of the deceased) does not exceed £1000, such property shall not be aggregated, but form an estate by itself. The executors or trustees or anyone to whom the property passes beneficially is liable to account for the duty. The property is to be valued at the market price at the time of the deceased's death. Special provision is made as to payment of the duty in respect of woodlands. Reasonable funeral expenses and all debts and incumbrances are deducted from the gross amount before the duty is assessed. Interest is due on the estate duty allocated on the moveable estate from the date of death, and on the duty allocated on the heritable estate from one year after the date of death, till paid at the rate of 3 per cent per annum. Duty is payable on the principal value at rates varying from 1 per cent on estates under £500 up to 14 per cent on estates not exceeding £1,000,000. Where the principal value of the estate exceeds £1,000,000, duty is payable at the rate of 15 per cent. Where the gross value of the estate exceeds £100 but does not exceed £300, a fixed duty of 30*s*. may be paid; and where the property exceeds £300 but does not exceed £500, a fixed duty of 50*s*. may be paid.

2. *Legacy and Succession Duty.*—In addition to estate duty, legacy or succession duty is payable on all estates except in the cases hereinafter mentioned. The legacy duty is payable in respect of gifts by will or testamentary instrument out of the moveable estate or on the shares of moveable property devolving under intestacy, while succession duty is payable in respect of the succession to heritable estate passing either under a will or on intestacy. The rates of duty on legacies, annuities, residues, and successions where estate duty has been paid, are as follows:—

Husband or wife, lineal ancestor or descendant of predecessor ...	1 per cent.
Lawful brothers and sisters or their descendants	5 ,,
Persons of more remote consanguinity or strangers in blood ...	10 ,,

Lineal issue and ancestors and the husband or wife of the deceased are exempt from the 1-per-cent duty in the following cases:—(*a*) Where the principal value of the property does not exceed £15,000, whatever be the value of the legacy or succession; (*b*) where the amount of the legacy or succession, together with other legacies or successions derived by the same person from the predecessor, does not exceed £1000, whatever may be the principal value of such property; (*c*) where the person taking the legacy or succession is the widow, or a child under the age of twenty-one years, of the predecessor, and the amount of the legacy or succession, together with any other legacies or successions derived by the same person from the testator, does not exceed £2000, whatever may be the principal value of such property.

A legatee or successor whose husband or wife is of nearer relationship is chargeable with duty at the rate at which such husband or wife would be chargeable. Relations of the husband or wife are chargeable with duty at 10 per cent unless themselves related in blood to the deceased.

[D. B.]

Suet is the name given to the aggregated masses of fat surrounding the kidneys, heart, and other organs, and in the omentum or 'apron'

which covers the intestines of animals used as food, more especially the ox and sheep. In beef suet, and still more in mutton suet, there is an excess of stearin, amounting to as much as three-fourths of the whole, so that these suets are hard and white. Healthy suet should be quite hard after the carcass has stiffened, containing neither jelly nor watery serum. When the abdominal fat of mutton is melted and strained so as to get rid of crude connective tissue, the result is the *sevum preparatum* of the B.P., melting at 103° F., a white, soft, homogeneous fat, almost odourless, greatly in use for making plasters, ointments, and cerates. Owing to its facilities for resisting decomposition, melted suet is often sprayed over a carcass so as to give it a thin but impervious coating of fat. Generally speaking, suet and body fat are constant in composition, whatever the source of food, as fat is partly derived from the carbohydrates in the foodstuffs and partly from proteid matters. The effects of food are most marked in affecting the colour, odour, and flavour, as is seen after oilcake feeding. [J. K.]

Suffolk Horse. — The Suffolk horse is undoubtedly one of the oldest breeds of British horses, but his origin is still conjectural, and the record of his early descent meagre and unilluminating. We learn from the writings of Arthur Young that the Suffolk Punch was known to his generation as an old-established breed in East Anglia, and that prior to the latter half of the 18th century the most unsightly points of the earlier type had been modified and the breed materially improved. Youatt, a succeeding writer, describes the original breed as 'standing from 15 to 16 hands high, of a sorrel colour, large headed, low shouldered and thick on the top, deep and round chested, long backed, high in the croup, large and strong in the quarters, full in the flanks, round in the legs, and short in the pasterns'. 'The present breed', says the same authority, 'possesses many of the peculiarities and good qualities of its ancestors. It is more or less inclined to a sorrel colour; it is a taller horse, higher and finer in the shoulders, and it is a cross with the Yorkshire, half or three-parts bred.' Youatt's reference to the Yorkshire cross is probably a guess on his part; so far as is known to the writer, the precise nature of the cross or the probable period when it was effected has never been definitely stated.

But whatever its origin, the original stock to which Young refers and which Youatt describes was undoubtedly improved by the infusion of extraneous blood, which served to impart to the Suffolk that lighter, more active, and smarter element which distinguishes the breed of the present day. The introduction of this alien blood took place for the most part previous to any records of the breed being kept; its source and nature are unknown, though its impress remains.

In later times there have been four horses of historical importance which have had a powerful effect in stamping the type of the modern Suffolk. The first and most notable of these is Crisp's Horse, a Lincolnshire trotting stallion, foaled in 1768, and the property of Thomas Crisp of Ufford, advertised in 1773 as 'a five year old, to get good stock for coach or road, a fine bright chestnut, full 15½ hands, noted for getting remarkably fine colts'. Most of the present-day Suffolk horses have a strain of the blood of Crisp's Horse in their composition. Next in importance is Blake's Farmer, foaled in 1760, and the sire of a noted family which has left its stamp on the breed. The last direct male descendant from the line passed from Britain in 1890. There was advertised in 1802 a beautiful chestnut horse, Farmer's Glory; this horse is also said to have come from Lincolnshire; a heavier horse than Blake's Farmer, he was the sire of many noted prizewinners. His stock were of exceptional size, though according to Biddell his stamp was not the style of the best Suffolk horse. This strain became extinct in the male line about 1870. Then comes Barber's Proctor, the pioneer of the Shadingfield stock: this horse, foaled in 1793, was the offspring of a chestnut mare and the son of a trotting horse of great substance. The descendants of Barber's Proctor were for the first few generations of a bay colour. Finally we have the Samsons, a strain of more modern date and of relatively small importance compared with those already mentioned. As with the other breeds, no direct descendants of the Samsons now exist, and the Suffolk horses of to-day all trace their pedigree through a line of some eighteen ancestors to Crisp's Horse of Ufford.

Points and Characteristics.—The Council of the Suffolk Horse Society have authorized the following scale of points for judging Suffolks:—

	Points.
Colour.—Bright-red or dark-chestnut are the favourite colours; a star, little white on face, or few silver hairs is no detriment	5
Head big, with broad forehead ... ... *Neck* deep in collar, tapering gracefully towards the setting of the head ... *Shoulders* long and muscular, well thrown back at the withers	10
Carcass deep, round-ribbed from shoulder to flank, with graceful outline in back, loin, and hind quarters; wide in front and behind (the tail well up, with good second thighs)	25
Legs should be straight, with fair sloping pasterns, big knees, and long clean hocks on short cannon bones free from coarse hair. Elbows turned in regarded as a serious defect	20
Feet having plenty of size, with good circular form protecting the frog	20
Walk smart and true	10
Trot well balanced all round, with good action...	10
Total	100

The Suffolk horse varies in height from 15¾ to 17 hands. In comparison with the generally massive body the legs are short, but they are hard and clean. The pasterns are short and strong, and free from much long hair. The bone should be of a flat, compact, flinty quality; large soft-boned legs are an undesirable feature. The shoulders are very long, lying rather forward to suit draught purposes. The hind quarters are also long and heavy, well knit, and closely coupled to the loin and back. The legs should be well set under the body; the girth should

Photo Chas Reid

SUFFOLK STALLION— BAWDSEY LADDIE

FIRST AT R A S E SHOW 1910

Photo Chas. Reid

SUFFOLK MARE—'SUDBOURNE SURPRISE'

FIRST PRIZE WINNER, R A S E SHOW, 1907

be large and the flanks well let down. A somewhat low forehead is not objected to, provided that the neck be strong and the head well formed and carried with spirit. In unison with other horse breeds, the Suffolk should be long, low, and wide.

The distinguishing characteristics which have made the Suffolk pre-eminent as a draught horse have long been associated with the breed. In 1813 Arthur Young, writing of the county of Essex, mentions the fact that the Suffolk at that period was the favourite horse in that county, and was noted for his hardiness and vigour. According to Youatt, 'the excellence, and a rare one, of the old Suffolk consisted of his nimbleness of action, his honesty, and the continuance with which he would exert himself at a dead pull. Many a good draught horse knows well what he can effect, and after he has attempted and failed no torture of the whip can move him to strain his powers beyond their natural extent. The Suffolk, however, would tug at a dead pull till he dropped.'

Formerly many interesting contests were held to determine the strength and value of special horses styled 'good drawers'. The horse which, after a series of twenty pulls and unprovided with a collar, raised the greatest weight was declared the winner. These contests were the occasion of many merry gatherings of masters and men, and provided that sport and excitement so dear to the heart of rural England. It was indeed a noble sight to witness a team of true Suffolks, at a signal from the driver and without the spur of the whip, putting forth their giant strength and dragging everything before them. The immense power of the Suffolks is partly accounted for by the low position of the shoulder, which enables the horse to throw so much of his weight into the collar.

The draught power and the tenacity of the old Suffolk, which made the breed famous in the past, have been transmitted in an undiminished degree to the stock of the present day. The value of the Suffolk is further enhanced by the fact that the breed is longlived—a characteristic which, in association with his splendid constitution, his unrivalled vigour, and his hardiness, has won for him an enduring reputation. A striking testimony to his longevity is borne by the fact that Julian's Boxer, a well-known horse in his day, was advertised as a stud horse for 25 years; in another instance the united ages of a mare and her foal (both exhibited at one of the early shows of the association) was 41 years. A team of four Suffolks, the property of Mr. Thomas Goodchild of Great Yeldham, continued to work together for 15 years without a break, and during that period not one of the team lost a single day through sickness. A case is on record of a Suffolk horse which continued to work in the London streets for 23 unbroken years, and had finally to be mercifully killed at the age of 29.

No breed of horses is adapted for such a variety of purposes as the Suffolk. As a farmer's horse he is held in high esteem. He is hardy and easily kept, thriving better than any other breed on long hours and short rations; he is a splendid horse for the plough; no dirt on his legs after a day's ploughing, and not subject to grease like the heavy, hairy-legged horses.

As a dray, or lorry horse, the Suffolk is a familiar object in the streets of some of our southern cities. For crossing with light-bred mares, the Suffolk is highly appreciated. Half-bred Suffolks are well adapted for heavy harness work. They make splendid brake horses, and none are superior for heavy wagonettes. Excellent specimens of heavy-bred Suffolks may be seen in the vans and drays of London; the Continental States use them as artillery horses. The offspring of a thoroughbred stallion and a pure Suffolk mare makes a valuable hunter, whose success has been proved in the show yard and in the field. Some years ago Mr. Scawen Blunt crossed Arabs and Suffolks and obtained a carriage horse adapted for doing long-journey work, and capable of maintaining a sustained trot of 8 to 10 miles per hour.

The management of Suffolk horses is similar to that of other draught breeds. The mares foal down as a rule during the months of April and May, and are allowed to run with their foals till August, when they are weaned. The foals are given a liberal allowance of crushed oats when they are taken from their dams, and this is continued through the first winter until there is sufficient grass in the spring for them to be turned out, after which date they have practically no corn; grass in the summer, with clover hay and roots the following winter, being considered sufficient. The colts are often broken to light work when they are two years old, being allowed a run off during harvest, and coming in for regular work when they are 2½ years. The ordinary working Suffolk horse leaves the stables at 6.30 in the morning and returns at 3 p.m., during which time he gets neither snip nor bite, his deep-ribbed carcass being adapted to these long hours without food. The Suffolk horse is an easy keeper; 5 st. of maize and bean-meal per week mixed with crushed oats and bran is the usual food allowance. Clover hay is fed at the rate of 1 cwt. per horse per week, with a few roots during the winter months.

The Suffolk has been exported to Canada, United States, and South America, to Australia and New Zealand, to Germany, France, Spain, Austria, Russia, and Sweden, and to the banks of the Nile, and has found favour wherever he has gone. In Australia the popularity of the Suffolk is rapidly increasing, because of his grand constitution and his ability to maintain condition on an allowance of food insufficient for other breeds.

The Suffolk Horse Society issues periodically a pamphlet entitled 'The Suffolk Horse, what he is, and where to find him'. Recent editions of this pamphlet contain advertisements of the leading studs, a few of which may be quoted here.

The largest stud in Great Britain is the Sudbourne Hall Stud, the property of Mr. Kenneth M. Clark; a large share of show-yard honours has already come home to Sudbourne Hall. In a competition at the Olympia Show (1910) open to all breeds, Mr. Clark won the championship with his team of Suffolk

geldings. One of the stud horses, Sudbourne Count (3257), has sired many notable prize-winners. Sir Cuthbert Quilter, Bart., who has for many years been president of the Suffolk Horse Society, is the owner of the Bawdsey Stud. The leading sire of this notable stud is Harvester (3076), thrice champion at the Suffolk County Show. The Rendelsham Stud, owned by Mr. Alfred J. Smith, has a reputation which extends over the seas, as being the home of famous Suffolks. Wedgewood (1749), the winner of the Queen's Gold Medal at Windsor, brought many trophies to his owner, and as a sire effected a marked improvement in the breed, especially in regard to feet. Saturn (2653), an offspring of this famous horse, secured no less than forty-nine prizes, and was the winner of many championships. This stud enjoys a large and increasing export demand. Other notable studs are the Morston Stud at Trimley, owned by Mr. Arthur J. Pratt; the Dennington Stud, the property of Mr. E. A. Cook; the Boulge Hall Stud, belonging to Mr. E. Eaton White; the Cockfield Stud, near Bury St. Edmunds, owned by Mr. Robert Edgar; the Lavenham Hall Stud, which has lately come into the hands of Mr. Cordy S. Wolton. Mr. A. Carlyle Smith and the Marquis of Graham are also owners of Suffolks whose reputation is in the making.

The Suffolk Horse Society publishes periodically a stud book, of which seventeen volumes have now been issued. In a recently published volume the entries recorded for 1908 and 1909 embrace 195 horses and 497 mares, animals mostly entered as foals. During the same period of two years the Society has granted 130 export certificates. Hence, according to these figures, it would appear that 20 per cent of the animals annually bred are exported. Doubtless also, some horses are exported for which no certificate is applied.

Sales are, as a rule, effected by private contract. The Suffolk Horse Society, however, holds an annual sale towards the end of July. At this sale the Society foals and surplus stock from other studs are disposed of. In 1909 the average price for foals was £22, 15s. In private sales it is difficult to give any precise figures. Useful stallions are sold for export from 100 to 250 gs., whilst first-class animals make up to 500 gs. There appears to be a fast-increasing demand for young mares suitable for breeding, these ranging in price from 60 gs. upward.

This article would be incomplete without some reference to the admirable work carried out by the Breeding Scheme Committee of the Suffolk Horse Society. The object of this scheme is to encourage the breeding of Suffolks amongst the smaller class of farmers by means of a hire-purchase agreement. Briefly, the scheme operates as follows: The Society provides each approved applicant with a brood mare costing not more than 60 gs., a quarter of which is paid by the farmer at the time of purchase. The farmer, in return for the use of the mare, agrees to pay interest at the rate of 4 per cent on the balance of all moneys spent by the Society on the mare. All Society mares are entitled to the Society's free nominations, and must be served only by a stallion approved of by the Societ[y]. The farmer must undertake to take good ca[re] of the mare and not to work her unfairly, an[d] to deliver the foals free of all cost and unweane[d] at Ipswich (or other appointed place), on th[e] day appointed by the Society for delivery [of] such foals. Provided that the foal is in goo[d] health and sired by a stallion approved of b[y] the Society, the farmer shall receive in respe[ct] thereof £16, 10s., such a sum being placed t[o] the farmer's account in the Society's book. Th[e] farmer also receives an equal share of any sum above 20 gs. which the foal may realize at th[e] Society's sale. These Society foals are sold un-reservedly, breeders being allowed to bid an[d] purchase on the same terms as the genera[l] public. Such a scheme as the foregoing canno[t] fail to have a marked effect in propagatin[g] among tenant farmers a high-class grade of Suffolk horses. [F. S.]

Suffolk Pigs have changed much of lat[e] years. Thirty or forty years ago they wer[e] mainly of a black colour, though some wer[e] quite white; they were neat, compact, an[d] comparatively small, weighing when fat abou[t] 170 lb., and possessing a somewhat large proportion of fat to lean meat. Some were long in side, snout, and legs, and of a slate colour, and having comparatively little fine hair. At the present time the neat compact pigs of the white or of the black colour have no place in Suffolk, whilst the long-sided, slow-feeding, but prolific black has been crossed by a thicker and heavier type of black pig commonly bred in the west of England, and has found an opening to appear as a pure-bred pig. Large numbers of the pigs fattened in the county of Suffolk at the present time are from these black sows and sired by a Large or a Middle White boar. These prove to be very profitable animals for the feeders, and very suitable for conversion into the famous Wiltshire bacon. [S. S.]

Suffolk Sheep.—In a pamphlet descriptive of this breed and written by the late Mr. Ernest Prentice, it is clearly shown that the Suffolk sheep is the result of crossing the old horned Norfolk—of which a few flocks still exist—with the Improved Southdown. For this reason the Suffolk combines in itself the hardiness and fecundity of the Norfolk ewe with the superior form and fattening properties of the well-bred and strong constitution of the Southdown, and has been recognized as a pure breed since 1810.

The rise of Suffolk sheep in public estimation has synchronized closely with the rapid development of the trade in chilled carcasses from the Antipodes, and live sheep from the vast grazing lands of North and South America; the severe competition created by these imports rendering it necessary for the breeder and grazier at home to seek a sheep which would yield them a good return and at the same time prove profitable to the butcher. The Suffolk sheep was found to meet the requirements of both parties, and its advance in favour has been speedy and sure, its merits resting upon the firm foundation of general utility, and the fact that the Suffolk is essentially a tenant farmer's sheep—by far

the majority of breeders representing a body of men who are seeking the means to ensure a profitable return upon their capital and skill—affords the surest indication of a still greater extension in the future.

In the early 'eighties a keen interest was aroused for pure-bred stock, and in 1886 the Royal Agricultural Society of England held their show at Norwich. To prepare for this and push the interests of Suffolk sheep, a large and influential meeting of breeders was held at Stowmarket on January 8, 1886, to consider the advisability of forming a society with this object. It was unanimously decided to form the Suffolk Sheep Society. A Council was elected, with the late Marquess of Bristol as president, and the late Mr. Ernest Prentice as hon. secretary. Classes were first added to the 'Royal' Schedule in this year.

The first volume of the flock book appeared in 1887 and others have since been issued annually. Later on, the Editing and General Purposes, and Veterinary Committees were elected from the Council; a veterinary inspector appointed, who from time to time issues a report.

At an early date the Council decided on the following points:—

Scale of Points

Head hornless. Face black and long, and muzzle moderately fine—especially in ewes. (A small quantity of clean white wool on the forehead not objected to.) Ears a medium length, black, and fine texture. Eyes bright and full	25
Neck moderate length and well set. (In rams stronger, with a good crest.) ...	5
Shoulder broad and oblique	5
Chest deep and wide	5
Back and loin long, level, and well covered with meat and muscle. Tail broad and well set up. The ribs long and well sprung, with a full flank	20
Legs and feet straight and black, with fine and flat bone. Woolled to knees and hocks, clean below. Fore legs set well apart. Hind legs well filled with mutton	20
Belly (*also scrotum of rams*) well covered with wool	5
Fleece moderately short; close fine fibre without tendency to mat or felt together, and well defined, *i.e.* not shading off into dark wool or hair	10
Skin fine, soft, and pink colour	5
Total	100

The distinctive feature of Suffolk sheep is the jet blackness of its head and of its legs below the knee and hocks, which should be covered with fine glossy hair, not mossy. A dark-faced sheep is undoubtedly a more marketable commodity as a first-class mutton producer than a white-faced one, and the prepotency of the Suffolks makes the rams of this breed valuable for crossing purposes, as the cross-bred progeny always bears the facial tint of their sire. The face should be fairly long with a fine muzzle, especially in the ewes, to ensure a good breeder and milker; the ear thin and silky and of fair length; the eyes full and bright, indicating a vigorous disposition, stamina, and fine quality.

One of the first and perhaps most unique steps taken to bring about the improvement of flocks of Suffolk sheep was the institution of flock competitions, challenge cups being offered from time to time by various donors. The cups have been given for various-sized flocks, that is, flocks of 350 ewes and upwards, flocks of not less than 250 ewes, and flocks of not less than 100 ewes. The flocks have to be shown uncoloured and 'untrimmed', and 10 ewe lambs per 100 ewes must be shown as a sample of the flock, with all rams used. A challenge cup is also given for the best lot of ewe lambs. The judging takes place in October, the judges visiting the farms of the competitors. These competitions have done much to raise the standard of excellence. In 1899 a gold cup, the 'Bristol Champion Challenge Cup', was offered by the Society for the best lot of ewes of not less than 120. Before this competition was started, a competitor could only say that he had the best flock in the class. This was given to see who in the opinion of expert judges had the best flock of the breed.

This gold cup has been held by the following flockmasters: 1899—S. R. Sherwood, Playford, Ipswich; 1900—H. E. Smith, Walton, Ipswich; 1901—Thos. Keeble, Bentley, Ipswich; 1902—Col. Baird, Exning, Newmarket; 1903—R. Barclay, Higham, Bury St. Edmunds; 1904—H. E. Smith, Walton, Ipswich; 1905—P. Eagle, Risby, Bury St. Edmunds; 1906—P. Eagle, Risby, Bury St. Edmunds; 1907—D. A. Green, Fingringhoe, Colchester; 1908—D. A. Green, Fingringhoe, Colchester; 1909—J. R. Keeble, Brantham, Manningtree.

All flocks are inspected prior to first registration, and in order to maintain a high standard of quality all registered flocks are re-inspected every fourth year. This periodical inspection has done much to raise the general standard and keep flock-owners up to the mark.

All sheep must bear the registered mark of the Society and the breeder's flock number tattooed inside the left ear, and rams the individual registered number inside the right. If carefully done these tattoo marks will last the lifetime of the sheep, and afford a great protection to purchasers.

Early maturity is one of the best tests of the value of a sheep, and Suffolks are well to the fore in this respect, as the following particulars will show. Well-grazed hoggets at the age of 8 to 10 months will yield 78 to 84 lb. of dressed carcass; when exceptionally well finished, somewhat more.

According to the statistics of the Smithfield Club, the average weight of pure-bred Suffolk sheep entered in the carcass competitions at that show for the five years 1905–9 is as follows:—

	Live Weight.	Carcass Weight.	Fat.	Pluck.	Skin.	Average percentage of Dressed Carcass to Live Weight.
Wether lambs under 10 months	142·6 lb.	89·6 lb.	9·1 lb.	4·8 lb.	13·8 lb.	62·85
Wether sheep under 22 months	175·8 lb.	114·8 lb.	12·0 lb.	5·2 lb.	13·8 lb.	65·27

The records for live weights for Suffolks exhibited at the Smithfield Club Show are as under:—

Wethers not exceeding 22 months ...	294 to 331 lb.
Lambs not exceeding 10 months ...	200 to 225 lb.

These figures compare favourably with any other breed, the Suffolk section having on more than one occasion furnished the heaviest pen of short-woolled sheep in the show. Ram lambs are so well forward at the age of 7 to 8 months that they are largely used for breeding purposes.

The annual returns collected by the Suffolk Sheep Society show the average number of lambs reared in registered flocks to have been 133·76 per 100 ewes for the past twenty years, and the average loss of ewes to be about 3·83 per cent.

Truly remarkable evidence of the quality of mutton is given in the Smithfield Club Show Carcass competitions, instituted 1895. From the first, Suffolks have given proof of their superiority. In 1895 one-third of the awards in the class for short-wool wether sheep not exceeding 24 months were gained by Suffolks. In 1896 one-third of the awards in the short-wool classes were gained by Suffolk lambs under the age of 10 months. In 1897 this success was repeated. In 1898 a Suffolk lamb obtained the Centenary Gold Medal for the best carcass in the yard. Since 1890, competing against representatives of nearly every pure breed, Suffolks and Suffolk crosses have been awarded the championship six out of ten years, the reserve for champion eight out of ten years, and the first prize for short-wool lambs the *ten years in succession*; besides approximately one-half of the total other awards in the short-wool and cross-bred classes.

Wool has an important bearing upon the constitution of the animal and upon the quality of its flesh, for a close dense fleece of fine fibre is needed to protect the sheep from the inclemency of the weather, and the density of the fleece cannot be lessened to any great extent without losing the essential fineness of grain in the mutton. For these reasons Suffolk breeders have always endeavoured to maintain a close fleece with medium length of staple. The average weight of hogget fleece on good soils is about 8 lb. per head of washed wool. Ewes will clip from 5 to 7 lb., and rams up to 14 lb.

All sheep to be eligible for the flock book must be the produce of a registered flock and bear the tattoo mark of the breeder in the left ear. They must also pass the inspector; sheep not considered up to the required standard are 'cull marked', having a hole punched through the left ear.

The principal flocks and those belonging to the most noted breeders are in Suffolk and Essex, and many in Cambridgeshire and Norfolk. There are also registered flocks in several other counties in England, also pure-bred sheep in Scotland, Ireland, and Wales. Many rams are distributed annually over Great Britain for crossing purposes, as they are much in demand to improve the mutton quality.

Registered flocks have also been established in France and Germany. There are several flocks of pure-bred sheep in the United Stat of America, where they have an American flo register. A few are also to be found in Au tralia, New Zealand, Spain, and Italy. The are two flocks on the Transvaal Governme farms, of high quality, where they have do wonderfully well, rams having been bred wi great success. Sheep of both sexes have al been sent to the Argentine, Chile, and mar other countries.

It is impossible in this article to enumera all the show-yard successes of Suffolks *in op competition with other breeds*. The following a those of special prominence:—

1895–6.—Championship at the Norwich Fat-sto Show.

1898.—Championship, Scottish National Fat-sto Club.

1899.—Prince of Wales's Challenge Cup for the be pen of sheep or lambs in the show (Smithfield Cl Show).

1900.—Smithfield Club Show. Prince of Wale Challenge Cup, for the second year in succession.

1901.—Championship of the yard at the Scotti National Fat-stock Show, for a pen of cross-bred lam by a Suffolk ram from half-bred ewes.

1902.—Scottish National Fat-stock Show. Chai pionship of the yard.

1902.—Smithfield Club Show. Champion plate in t short-wool section.

1907.—Championship of the yard, Scottish Nation Fat-stock Show. Suffolk-Border Leicester cross p of three under nine months old, scaling 737 lb.

Chief Markets.—*Ewe lambs*: Great Bentle Sutton (Woodbridge), and Kesgrave (Ipswich in June and July. *Ewes and rams*: Ipswic and Newmarket in August and September.

Prominent Breeders.—The names of t 'Gold Cup' holders have already been give The following have all first-class registere flocks, and have been the most promine winners at the Royal, Smithfield, and Count shows: H. E. Smith, Walton, Ipswich; D. Green, Fingringhoe, Colchester; S. R. She wood, Playford, Ipswich; J. W. Eagle, Walto on-Naze, Essex; R. Barclay, Higham, Suffoll J. R. Keeble, Brantham, Manningtree; T. Goo child, Great Yeldham, Essex.

Record Prices

1898.

	Highest Price.	Average.
48 ram lambs from one breeder ...	£63 0 0	£14 11 0
123 shearling ewes ...	15 10 0	7 12 0
52 two-shear ewes...	26 0 0	10 12 0
127 ewe lambs ...	10 10 0	4 6 0

1899.

Highest price for ram lamb ...	£152 0 0
Next highest price	105 0 0
Shearling ram	99 15 0
40 shearling ewes from one breeder, per head	11 0 0

1908.

21 ram lambs from one breeder averaged per head	23 16 6

1909.

400 ewe lambs from one breeder averaged per head	2 10 6
Highest price for ram lamb ...	60 18 0
Shearling ewes made up to, per head	9 0 0

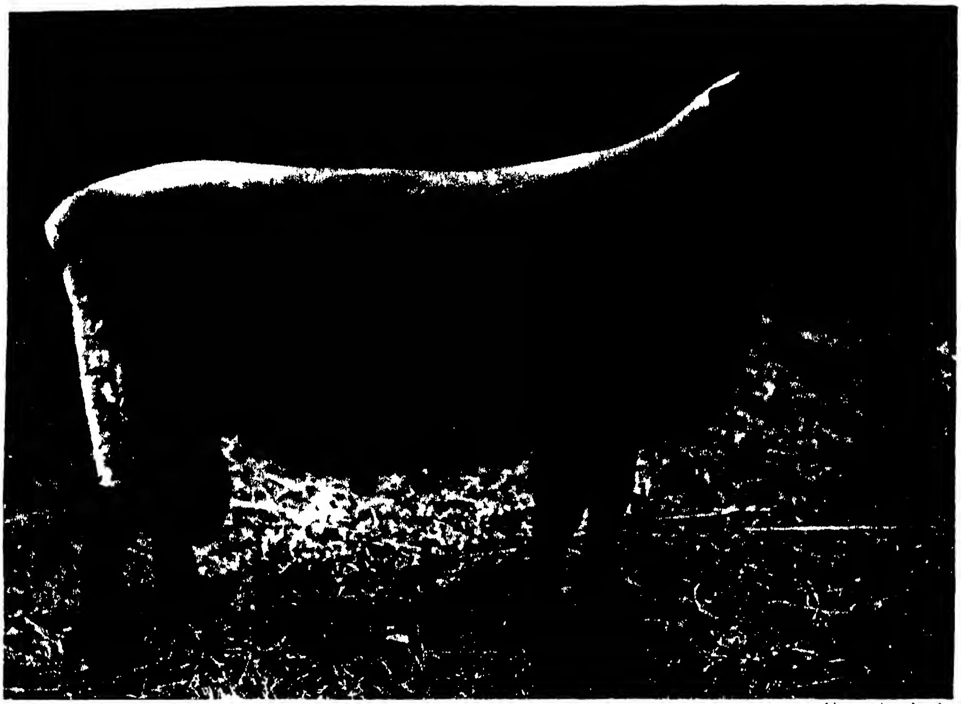


Photo Chas Reid

SUFFOLK SHEARLING RAM

FIRST AT R.A.S.E. SHOW 1910

(10)

Photo Chas Reid

SUFFOLK EWES

FIRST PRIZE PEN, R.A.S.E. SHOW, 1907

Flocks in East Anglia are mostly kept on arable land, being folded in hurdles at night, with a run out during the day on heathland, saltings, clover, and mixed leys or pasture. The ram breeding flocks lamb down as early in the year as possible; a plentiful supply of food being ready, such as cabbages, kale, kohlrabi, coleseed, mangel, turnips, &c., and early rye. Both ewes and lambs are kept with a liberal supply of food, the lambs running forward through creeps into the fresh fold, having what trough food they will clear up. This generally consists of a mixture of linseed cake, crushed oats, cracked beans or peas, with bran or malt culms. When the lambs get to eat a good lot of this, the trough food of the ewes is proportionally decreased. Early rye grass, trifolium, red and white clover, and later on kale and tares, form the main staple for feeding; plenty of mangel is always kept for late spring and summer use. Lambs are docked and castrated when about three weeks old, and marked to show how bred. Most flocks lamb down the latter part of February or early in March. [S. R. S.]

Sugar Beet. See art. BEET.

Sugar Cane is the grass *Saccharum officinarum*, Linn. (nat. ord. Gramineæ), the stems of which are highly charged with a sweet (saccharine) juice, from which crystallized sugar is manufactured. It seems fairly certain that the cultivation of sugar cane originated in southern Asia, if not in India; at all events it was there known and valued for many centuries before it had reached the other countries in which it is now extensively cultivated. The Venetians obtained it from India in 1148 A.D. It was grown in Sicily and carried from thence to Madeira in 1419, and to Brazil, St. Domingo, and Barbados a century later. It reached Morocco and Egypt about 1492, and Sierra Leone and Gambia in 1620. In 1782 we read that the special Otaheite cane had been conveyed to Trinidad and Martinique. So late as 1647 Ligon found sugar cane but little understood in Barbados, but toward the close of the 18th century it had been carried by the French to Louisiana. At the present day, sugar cane is grown throughout the tropics and sub-tropics, and even in certain warm temperate tracts; especially in India, China, Indo-China, the Malaya, the West Indies, Mauritius, British Guiana, &c., and at Malaga in Spain.

It is thus originally a tropical plant, and requires a hot, moist atmosphere, alternating with periods of dry weather. Rich porous clays or alluvial soils are best suited; in other words, a mixture of clay and loam with plenty mineral matter, especially lime. It is an exhausting crop, and cannot be grown on the same soil continuously unless liberally manured. Proximity to sea breezes seems to be advantageous, hence the success attained in insular situations. The vicinity to streams, so as to secure subsoil moisture, is distinctly a valuable condition. It is a gigantic grass, the stems of which (produced in clumps) may be from 3 to 12 ft. in height and ½ to 2 in. in diameter. About October certain of the canes produce flowering shoots (the arrows as they are called), but these only very rarely become impregnated. In consequence the cane rarely fruits, so that reproduction for the most part has to be by stem cuttings of two or three joints. These should be taken from about the middle of strong healthy stems; not the useless tops, only too often so utilized in selfish and shortsighted cultivation. Unfortunately the planters in most countries have not given the selection of stock the attention which the importance of the subject demands. Diversity has been attained from accidental sports and climate variations, though recently it has been found that almost any desired stock can be readily procured through crossbreeding the existing plants, and thus producing valuable seedlings. It has been affirmed that a good cane is one that will yield 70 per cent of juice, which will ultimately afford 15 per cent of sugar, and which contains not more than 17 per cent of glucose. The following are the chief canes of commerce:—

1. Mauritius, perhaps only a violet Javan cane.

2. Otaheite, a yellow or straw-coloured cane with broad leaves of a pale green and which droop considerably, especially on nearing maturity.

3. Bourbon, Réunion, or Madagascar.

4. Batavian: various kinds, such as the yellow-violet, purple-violet Javan, and the transparent or ribbon canes. The yellow-violet is smaller and less juicy than the Bourbon and Otaheite, but more hardy, and has the foliage dark-green and erect. The purple-violet is much thicker, the joints very long, and the leaves very dark green; it is rich in juice, but difficult to grind. The transparent or ribbon is bright yellow, blotched with red; its chief merit turns on the fact that it will grow on light soils almost unsuited to any other canes.

5. China: these are hardy and prolific, not liable to be attacked by white ants nor jackals, and able to withstand the hot weather.

6. Singapore: the canes of this class hardly differ from those of Batavia and Bourbon. The best known is the Selangore, distinguished by the large amount of white powder or blush on the surface. The leaves are very broad and deeply serrated on the edges, also dark-green in colour. It is closely allied to the Otaheite. The red-purple cane of Singapore and the red cane of Bombay are perhaps identical.

Apart from the race of plant grown, and the improvements that have been and are possible in the stock, there would seem a wide range in yield of cane to the acre, in percentage of juice afforded, and in the amount of crystalline sugar available, due very possibly to climate, soil, and method of cultivation pursued. Few crops, in fact, respond more immediately and profitably to liberal treatment. And what is perhaps even more curious, there are such differences in methods and results of manufacture, that in some countries with a low yield of cane, sugar is nevertheless produced at quite as reasonable a figure, and with an even more satisfactory result financially, than in others where nature seems exceptionally bountiful. The yield of cane to the acre has been thus stated: 36 tons

in Java, 33·4 in the Sandwich Islands, 30 in British Guiana, 22 in Egypt, 15 to 20 in India, 16 in Queensland, and 15·2 in Japan. So in the same way the yield of sugar to the acre has been given as follows: a little under 1 ton to the acre in India, 1·1 in Japan, 1·6 in Queensland, 1·8 in British Guiana, 2·2 in Egypt, 3·6 in Java, and 8 in the Sandwich Islands. According to some estimates the West Indies give as much as 3 tons of sugar to the acre, to others only about half that quantity. But as indicative very possibly of improvements accomplished in manufacture, it is stated that in Java sugar costs £8, 12*s.* 6*d.* and in Queensland £8, 15*s.*, notwithstanding that in the former the yield of cane is double that of the latter.

The tillage pursued depends largely on the intelligence and resources of the cultivator. When grown as an occasional crop in rotation with others, sugar cane is regarded as beneficial, since unless the land be liberally ploughed and generously manured it will not pay, and the crops that follow thus benefit from the effort put forth in sugar-cane production. It is customary in India, for example, to allow the land to lie fallow for a year before planting, and to plough and harrow it in the interval from twenty to forty times; oilcake, farmyard manure, and (when indicated as necessary) lime are the manures resorted to. On the other hand, in countries where rotation is not possible or desirable, such as in many parts of the West Indies, the fertility of the soil is preserved by systematic manuring with farmyard manure, guano, gypsum, superphosphate, and other manures.

It is customary to preserve the cuttings or sets in a pit from the harvest season to the ensuing planting time. In some localities the cuttings are sprouted in a nursery and in others planted direct into their final positions, or 'plants' are obtained from 'ratooned' stocks. They are usually assorted along the crest of the ridges, made across the field in the final preparation of the soil, or they are deposited in special holes, in fallow land, dug to a depth of 2 ft. and separately manured. Formerly the plants were set much closer than is commonly the case in larger plantations to-day. Three feet between the ridges and 2 ft. from each other were ordinary distances, and sometimes even closer. But it is now preferred to give spacings double those mentioned. On rich soils the distances apart may be increased, and on poor soils decreased, thus providing for the growth likely to ensue. It is also customary to place two cuttings at each place, and to bury these in a slanting position, 5 or 6 in. below, and 1 in. left above the surface. At each of the joints below, a bud will form which will send shoots upwards and roots downwards. These first-formed shoots are called the 'mother plants', and it is usual to nip the tops off as soon as two or more joints have formed aboveground. This pruning causes a copious branching, which results in each stool becoming a dense clump of canes. Vacancies that become manifest are best filled up from a surplus stock in the nursery. The seasons of planting and reaping vary greatly according to the climatic conditions of the countries concerned. In India, for example, the planting season varies from November up to April, the most general being February and March. In the West Indies the planting time is October to January. The reaping season in India ranges from November to January, and in the West Indies from January to May.

During the growing season constant weeding is necessary until the canes have elongated sufficiently to check the growth of weeds. Occasionally also a light ploughing is given, between the lines of canes, and in most localities watering, from three to twelve times during the growing season, may be necessary, but excessive watering is dangerous. As the plants grow the lower leaves wither, but usually remain attached to the stems. In dry weather these leaves must be left alone; but in localities with heavy moisture, on the approach of maturity, it may be necessary to remove the leaves so as to secure a freer circulation of air. In India it is also a frequent practice to bind the top leaves of two or three shoots together, thus bringing the canes into compact clumps, and thereby saving them from being blown over or broken by the winds; this also checks the ravages of jackals. If the leaves have begun to change colour and the buds on the shoots (the eye-buds as they are called) have been fully developed, the canes are ripe for being cut. The skin will then be seen to have become dry, smooth, and brittle; the juice will be sweet, and the inner tissue dry and gritty, whereas in unripe canes it is soft, moist, and pulpy.

After the canes are cut from the field they are tied into bundles and carried off to the mill, where they are crushed and the juice thus extracted. Since the juice is very subject to become fermented and thus seriously injured, it has to be boiled down to a thick coarse sugar as soon as possible. In the smaller factories that is all that is attempted, the raw or muscovado sugar being consigned to the refineries to be crystallized. But in the larger concerns, complicated and expensive machinery is employed by which crystalline sugar is at once produced. It would be beyond the scope of the present article to deal with these, but briefly it may be said the two chief methods of obtaining the sugar from the cane are (*a*) crushing and (*b*) diffusion. By the first the supply of ripe canes is regulated by the capabilities of the factory. Various kinds of mills are used, all more or less developments of the crude hand-mills still in use in India. The canes are passed between rollers which either work horizontally or vertically. And they are so adjusted as to give the desired pressure. The canes are broken up, the juice squeezed from them, and the *megass* or bruised residue is in the more primitive factories used as part of the fuel for boiling down the juice. But by the crushing process the whole of the juice is not removed, and this fact has recently led to the adoption of the second process, where a far greater proportion of the saccharine fluid is removed. In place of crushing, the canes are sliced in a slanting direction into thin pieces $\frac{1}{16}$ in. in thickness, and these

are at once conveyed to the diffusion batteries, where they are subjected to water at a very high temperature. This coagulates the albumen and extracts practically all the sugar from the cells. It is also maintained that an economy of power is effected in slicing and macerating rather than by crushing the canes. [G. W.]

Sugars.—The term 'sugar' was formerly applied to all sweet-tasting substances, but in modern times has come to be limited to the crystallizable sweet principles of plant juices, notably those of the sugar cane and sugar beet. The chemist now uses the term 'sugars' as a collective name for a large number of such substances, some of which have been isolated from vegetable or animal matters, whilst others are purely artificial products. They are all closely related in chemical composition and belong to the important group known as the carbohydrates (see art. CARBOHYDRATES).

These sugars are all colourless, crystallizable, sweet-tasting substances, easily soluble in water, readily decomposed on heating, giving first brown caramel-like products, and finally a black mass of carbon. Many of them are easily oxidized, as is evidenced by the red precipitate of cuprous oxide that they produce when warmed with an alkaline solution of copper sulphate. The sulphate of copper is said to be reduced, and hence the name of 'reducing sugars' is often applied to those sugars which react in this way.

Out of the numerous sugars now known, only a few are of practical importance. These commonly occurring sugars belong to two classes, viz.:—

A. *Monosaccharoses, or Glucose Group.* Also termed hexoses or monoses. *Chemical formula,* $C_6H_{12}O_6$.

Examples.—Glucose (dextrose, or grape sugar).
Fructose (lævulose, or fruit sugar).
Galactose.

B. *Disaccharoses, or Cane-sugar Group.* Also termed hexobioses or bioses. *Chemical formula,* $C_{12}H_{22}O_{11}$.

Examples.—Sucrose (cane or beet sugar).
Maltose, or malt sugar.
Lactose, or milk sugar.

The disaccharoses are derivatives of the monosaccharoses, two monosaccharose molecules interacting together with elimination of the elements of water and production of a disaccharose.

$$2C_6H_{12}O_6 - H_2O = C_{12}H_{22}O_{11}.$$

This process can indeed be easily reversed if the disaccharose be submitted to the action of acidulated water or an appropriate enzyme. Water is then brought into chemical reaction with the disaccharose molecule, and brings about its dissolution into the two monosaccharose molecules from which it was originally built up. Thus when treated in this way

Sucrose gives glucose + fructose.
Maltose ,, glucose alone.
Lactose ,, glucose + galactose.

Not only are the monosaccharoses the parent substances of the disaccharoses, but the dextrins, starch, and cellulose are also derived from them in similar, although more complex fashion. The monosaccharoses are the first carbohydrates produced from carbonic acid in the green parts of plants, their creation being a necessary preliminary to the formation of other carbohydrates (starch, cellulose, &c.), oils, vegetable acids, and probably many albuminoids. Furthermore, when the carbohydrates of plants undergo digestion in the animal body they are resolved again into monosaccharoses. These monosaccharose sugars must therefore be regarded as of fundamental importance in connection with the vital activities of both plants and animals.

The following summary will serve to indicate the distribution and characteristics of the common sugars tabulated above.

GLUCOSE (dextrose, or grape sugar) is the most widely distributed of sugars. It occurs, usually along with fructose, in practically all plant juices in greatly varying proportions. It is the chief sugar in unripe fruits, but as ripening progresses the proportions of fructose and sucrose increase. It is also present in appreciable quantities in turnips and in the young shoots of grasses or corn. Its chief occurrence in animal products is in honey, which commonly contains about 40 per cent each of glucose and fructose, along with 16 to 18 per cent of water. It occurs in small proportion in the blood, and in cases of diabetes is found in appreciable quantities in the urine.

Glucose is manufactured in large quantities from starch. The starch is heated with dilute sulphuric acid under pressure until the conversion to glucose is complete. The free acid is then neutralized with lime, and the clarified liquor evaporated down to obtain the glucose.

Pure glucose is a colourless crystalline substance, easily soluble in water, sparingly soluble in alcohol. It differs from ordinary sugar in being less sweet, directly fermentable to alcohol by brewers' yeast, and in possessing reducing properties. It enters into the constitution of all the common disaccharoses, and also of dextrin, starch, and cellulose, so that in many respects it is the most important of all carbohydrates.

It is largely used as a cheap substitute for ordinary sugar in the making of jam, confectionery, liqueurs, wines, &c., and as a substitute for malt in the brewery.

FRUCTOSE (lævulose, or fruit sugar) occurs along with glucose in most sweet fruits, 'roots', and honey. It may be obtained along with an equal amount of glucose by boiling ordinary sugar with dilute acids or subjecting it to the action of the enzyme *invertase.* The mixture of sugars thus obtained is known in commerce as 'invert sugar'. Pure fructose is most conveniently obtained by the action of dilute acid upon the carbohydrate *inulin* (found in the Jerusalem artichoke and a few other plants).

Fructose is, in the main, very similar to glucose, but differs in being more soluble in water, more difficult to crystallize, and less rapidly fermented by ordinary yeast.

GALACTOSE is chiefly of importance in its relation to the sugar of milk (lactose). It is not widely distributed as such, and in general character and properties resembles the other monosaccharose sugars. It may be obtained by the action of dilute acid upon lactose or many gums.

Sucrose (cane- or beet-sugar; saccharose) is the most valuable commercially of all sugars. It occurs very widely distributed in plants, notably in the sugar cane (15 to 20 per cent) and in the sugar beet (14 to 17 per cent). It is also present in moderate proportions in mangels and carrots (6 to 10 per cent), the stems of young maize (5 to 7 per cent), the spring sap of the sugar maple (7 to 9 per cent), and in many fruits. It has been manufactured from the sugar cane from the very earliest times, and from the sugar beet since the later years of the 18th century. The processes are practically identical, whether the cane or the beet be used as raw material.

The cane is crushed between iron rollers to express the juice (or the beet cut up into small portions), and thoroughly extracted with water. The extract (containing besides the sugar, small quantities of albuminoids, organic acids, salts, &c.) is filtered, heated nearly to boiling, and treated with milk of lime in order to neutralize acids and precipitate albuminoids that have passed into solution with the sugar. The excess of lime is removed by passing carbonic acid gas through the hot dark-brown liquor, which is then decolorized by treatment with sulphur dioxide. The filtered liquor is then evaporated down under reduced pressure until the sugar begins to crystallize out. The brown crystals are separated from the viscous dark-coloured mother-liquid (molasses) by the application of centrifugal force, and are purified by washing with pure sugar solution and recrystallization. Further quantities of crystallized sugar can also be obtained from the molasses by special processes, but a residuary molasses always remains containing sugar which cannot be profitably extracted in crystalline form. This is either fermented to rum or used for feeding purposes. See Molasses.

Sucrose is easily soluble in water, but almost insoluble in alcohol. On long boiling with water it loses its property of crystallization. On heating to 160° C. it melts, and if then cooled solidifies in the transparent, non-crystalline form of 'barley sugar', which gradually becomes crystalline and loses its transparency. If more strongly heated (190° to 200° C.) it becomes coloured first yellow, then gradually deepening to dark-brown as the sugar is converted into caramel. At still higher temperatures it decomposes, with separation of carbon and evolution of considerable quantities of combustible gases.

Sucrose does not reduce alkaline copper solution, and is not directly fermentable to alcohol, but must first be converted into 'invert sugar'. Ordinary yeast contains an enzyme (*invertin*) which is capable of effecting this necessary preliminary to the alcoholic fermentation. A useful property of sucrose is its power of combining with lime and similar bases, forming easily decomposable saccharates.

Sucrose is now a universal article of human diet, and is used in immense quantities in a great variety of ways, *e.g.* for sweetening food and drink, for confectionery, and as a preservative for fruit in jam-making, fruit-bottling, &c.

Maltose (malt sugar) occurs in small quantities in most plants, notably in germinating seeds. It arises, along with dextrin, from the action of the enzyme *diastase* upon starch. Use is made of this property in the manufacture of alcohol and various alcoholic liquors from starchy materials, the diastase being supplied in the form of germinated barley (malt) or other cereal grain.

Maltose is very similar in character to glucose, showing reducing properties, and being capable of direct fermentation to alcohol. It is readily converted to glucose either by the action of dilute acid or by the enzyme *glucase*.

Lactose is only found in milk, cow's milk containing usually from 4½ to 5 per cent. It is obtained from whey by evaporating down (best under reduced pressure), after first removing albuminoids and neutralizing acids present by an addition of lime.

It is less soluble in water and less sweet than ordinary sugar, and can reduce alkaline copper solution slowly at boiling temperature. It is not directly fermentable to alcohol by ordinary yeast. On boiling with dilute acids, or treatment with the enzyme *galactase*, it gives a mixture of glucose and galactose. Certain bacteria with which milk is always contaminated readily convert it into lactic acid. It is the most slowly digested of all sugars. [C. C.]

Suint is the name given to the potash compounds deposited on sheep's wool from perspiration. It is a mixture of oleate, palmitate, chloride, sulphate, and sudorate of potassium. Being soluble in water, the greater part of the suint is removed from the fleece when the sheep are washed before shearing. In the case of Merino sheep it amounts to one-half of the weight of the unwashed wool, in ordinary sheep it varies from 30 to 40 per cent of the total weight of the fleece. The utilization of suint as a source of potash is practised in France, Belgium, and Germany. Instead of the wash water escaping into the drains, it is either allowed to run on to the land, or it is evaporated and the residue incinerated. The cinder left yields its potash by treatment with water. On an average, raw wool yields 4 per cent of its weight of pure potash. [R. A. B.]

Sulphate of Ammonia.—Ammonia is a pungent gas remarkable for its great solubility in water and for its basic properties; it combines energetically with almost all acids. It is a compound of nitrogen and hydrogen represented chemically by the formula NH_3, and its compound with sulphuric acid, commonly called sulphate of ammonia, is $N_2H_8SO_4$. The pure sulphate of ammonia therefore contains 25·8 per cent of ammonia or 21·2 per cent of nitrogen. The commercial material, which should not have more than 5 per cent of impurity, will thus contain not less than 20·2 per cent of nitrogen or 24·5 per cent of ammonia. While generally sold in a fair state of purity, containing chiefly tarry matter and moisture as harmless contaminations, ammonium sulphocyanate is sometimes present, which is poisonous to vegetation; this can be readily detected by the red colour it gives with perchloride of iron. Sulphate of ammonia may be readily recognized

by the strong ammoniacal odour it emits on heating with an alkali or with lime or chalk. When heated on a shovel to dull redness it should leave no residue, showing its freedom from adulteration with fixed substances such as common salt. The chief source of ammonia is coal; this on being heated in the process of coal-gas manufacture yields part of its nitrogen in the form of ammonia. The ammonia is converted into sulphate of ammonia, and put on the market at a price which constitutes it one of the cheapest, as it is also one of the most valuable, of the nitrogenous manures.

When brought into the soil, sulphate of ammonia undergoes three chemical changes: (1) it reacts with the carbonate of lime in the soil to produce carbonate of ammonia and sulphate of lime, the latter being then leached out of the soil in the drainage; (2) the ammonium radicle reacts with the zeolites of the clay and with the lime salts of humic acids so as to fix the ammonia and to liberate a corresponding quantity of sodium or calcium; (3) the ammonia is oxidized by the nitrifying bacilli first into nitrite then into nitrate of lime, a supply of oxygen and of carbonate of lime (perhaps in some cases silicate of lime or other basic materials) being necessary for the reaction. This nitrification proceeds but slowly in cold weather, but as the temperature rises it progresses rapidly under favourable conditions, of which the most important is the free access of air to the soil. So long as the ammonia remains unnitrified its combination with zeolites and with the acids of humus prevents its loss by drainage in all but the lightest soils; but as it becomes converted into nitrate there is nothing to prevent any that is not absorbed by the roots of plants being lost if and when there is sufficient rainfall to cause the drains to run. In the process of nitrification, ammonia is converted by oxidation into nitric acid, and both this and the sulphuric acid with which it was combined have to be neutralized by a base. In this way 1 cwt. of sulphate of ammonia will deplete the soil of about 1½ cwt. of carbonate of lime, though this effect is somewhat reduced by the fact that, in absorbing nitrates from the soil, plants return thereto a considerable proportion of the base with which the nitric acid was combined. Nevertheless it is not wise to use sulphate of ammonia on soils poor in carbonate of lime. But where the poverty in carbonate of lime is not extreme, by mixing sulphate of ammonia and nitrate of soda in equal proportions the objection to the use of the former is obviated.

It follows from what has been stated above that, in cold weather especially, sulphate of ammonia is somewhat slower in action than nitrate of soda, and also somewhat less readily washed out of the soil. But as compared with manures containing nitrogen in organic combination, sulphate of ammonia is a quick-acting manure. In fact it may be put thus: that organic manures are more or less quick acting in proportion as they are more or less quickly converted into ammonia. Sulphate of ammonia at £12 per ton costs only about 11*s.* 9*d.* per unit of nitrogen, and is as cheap as nitrate of soda at £9 per ton or thereabouts. It is therefore, in all cases for which it is suited, one of the most economical of all manures. When it is required to provide a steady supply of nitrates over the whole period of active growth, some organic manures, such as guano, for instance, have definite advantages; but as only a part of their nitrogen becomes available even during a whole year, it is evident that in many cases they cost more in proportion to the nitrate supplied for the current year's crop. For example, dissolved bones might often be advantageously replaced by a mixture of sulphate of ammonia and superphosphate on soils not poor in carbonate of lime; kainit or sulphate of potash being added or not, as required.

As compared with nitrate of soda, sulphate of ammonia is to be preferred for malting barley; for wheat the choice between these two manures is more dependent on conditions of soil and season; but nitrate of soda gives the greater yield of straw. Amongst root crops, sulphate of ammonia is better for potatoes, but nitrate for mangolds and (in small quantities) for swedes. For grassland nitrate has the advantage that it encourages deeper rooting and the deeper-rooting species, and thus makes the meadow more capable of resisting drought.

Sulphate of ammonia should not be mixed with basic slag nor with lime or carbonate of lime, as these would liberate the ammonia and render it liable to be lost; but the affinity of the soil for ammonia is such, that no loss will accrue from putting either of these materials on the land at the same time as sulphate of ammonia. [C. M. L.]

Sulphate of Copper (Copper Vitriol, Blue Vitriol, or Bluestone), $CuSO_4 5H_2O$, the most important salt of copper, occurs in the drainage water from copper mines, and is obtained as a by-product from various metallurgical industries. It crystallizes in large transparent blue crystals which dissolve fairly easily in cold water, especially if finely powdered, but are much more soluble in hot water.

Copper sulphate is largely employed for the destruction of charlock, for the pickling of seed wheat to prevent smut and bunt, and for the spraying of potatoes, &c. In purchasing sulphate of copper, the pure salt, guaranteed to contain 98 per cent copper sulphate, should always be specified. The so-called 'agricultural bluestone' is very impure, and sometimes contains as much as 20 per cent sulphate of iron, which renders it much less effective. It should also be obtained either ground or in the form of small crystals, as both these forms are much more readily soluble than the large crystals of the salt. Solutions should be made up with clean soft water, always in wooden vessels, as iron and zinc are attacked by the sulphate of copper. Copper sulphate is poisonous, and solutions of it, or the vessels employed in making them, should never be left in the way of farm animals.

Pickling of Grain.—For the prevention of bunt and smut in cereals, two methods may be adopted: the seed may either be steeped for twelve to sixteen hours, with frequent stirring,

in a ½-per-cent solution of the copper sulphate, or the grain may be spread on the floor and watered with a 10-per-cent solution of the salt. For the latter treatment 1 lb. of copper sulphate dissolved in 1 gal. of water is sufficient for about 4 bus. of seed. The seed, after treatment, should be spread out in a thin layer to dry. See OATS and BARLEY—PARASITIC FUNGI.

Charlock Spraying.—The usual amounts applied for this purpose are 40 gal. of a 4-per-cent solution, or 50 gal. of a 3-per-cent solution per acre. 3 lb. copper sulphate in 10 gal. of water gives a 3-per-cent solution, and 15 lb. dissolved in 50 gal. of water will therefore serve to treat 1 ac. See MUSTARD WEEDS; CHARLOCK; SPRAYING.

Potato Spraying.—For the prevention of potato disease the copper sulphate is applied in the form of 'Bordeaux mixture', prepared by adding slaked lime to a solution of the sulphate, whereby the copper is precipitated as a basic salt. 9½ lb. copper sulphate, 9½ lb. freshly burned quicklime, and 100 gal. water are the proportions commonly employed. Recently, however, a more dilute solution has been shown to give equally effective results: copper sulphate, 2 oz., saturated lime water, 13½ pt., and water to make up to 9½ gal. This mixture can be had in the form of 'Woburn Bordeaux Paste', which is equally effective; 15 lb. paste to 100 gal. water is the strength employed

The quicklime is first slaked, and then the bulk of the water added, and the mixture stirred from time to time for half an hour. Then, after standing a short time, the copper sulphate, dissolved in a little water, is added, and the mixture well stirred. Further stirring should be avoided.

The mixture should contain no copper in solution. A little of the mixture is placed in a white saucer, and a few drops of a solution of potassium ferrocyanide (obtainable from any chemist) added. A reddish-brown colour will appear if copper is present; in such cases more lime is added until the copper is all precipitated.

Soda Bordeaux. — In this case 17½ lb. carbonate of soda (washing soda) is used in place of the lime. The soda is dissolved in water and the solutions mixed as before.

Bordeaux mixture is also used in the treatment of various fungoid diseases of trees.

Footrot in Sheep.—A 10-per-cent solution of copper sulphate (1 lb. to 1 gal. of water) is used as a footbath for the prevention and cure of this disease. See FOOTROT IN SHEEP. [A. L.]

Sulphate of Iron (Green Vitriol, Copperas, or Ferrous Sulphate), $FeSO_4$, $7H_2O$, is prepared from iron pyrites, either by roasting or by exposing the pyrites to the oxidizing action of moist air. It is readily soluble in water. A solution of sulphate of iron readily undergoes oxidation on exposure to the air.

Sulphate of iron is largely employed as a fungicide and as a winter wash for the destruction of lichens and moss on the trunks and branches of fruit trees. For the latter purpose a 10-per-cent solution of the salt (1 lb. sulphate of iron in 1 gal. water) is commonly employed. See art. FUNGICIDES.

Sulphate of iron was formerly used to a certain extent in place of sulphate of copper for the destruction of charlock. As a much stronger solution is required (15 per cent), and as the solution readily undergoes oxidation and is unpleasant to handle, it is now infrequently used.

The use of sulphate of iron as a manure has been suggested from time to time. The amount of iron required by plants, however, is excessively small, and most soils are abundantly supplied with iron compounds, generally in a sufficiently soluble form to be readily available for plant use. There appears to be no sufficient evidence that sulphate of iron is of value as an iron manure. The beneficial effects said to follow a dressing in gardens may be the result of its action as a fungicide and not because it supplies iron to the soil. Its use has been recommended as a remedy for chlorosis when this is due to a deficiency of available iron salts in the soil. [A. L.]

Sulphate of Lime. See GYPSUM.

Sulphate of Potash, or **Potassium Sulphate** (K_2SO_4), is a white crystalline salt which is easily soluble in water. It can be obtained by acting on the chloride or carbonate of potash with sulphuric acid, and is, to a certain extent, prepared in this way. But the largest quantities are obtained from crude salts found in the German potash mines, which contain sulphate of potash along with salts of sodium and magnesium. Sulphate of potash is used extensively as a manure, but there are also large quantities used for other purposes.

The output from the German potash mines, which are the principal source of supply, has been as follows:—

	Sulphate of Potash.	Sulphate of Potash-Magnesia.
1886	3,639 tons.	10,111 tons.
1896	13,889 ,,	4,622 ,,
1906	51,198 ,,	37,110 ,,

In addition to that obtained from Germany, a considerable amount of sulphate of potash is made in Scotland from the ash of seaweed.

The sulphate of potash used as manure is of various grades of purity. The highest grade contains about 98 per cent of potassium sulphate, corresponding to over 52 per cent of pure potash, while a lower grade contains about 90 per cent of potassium sulphate, corresponding to about 48 per cent of pure potash. The double sulphate of potash-magnesia, which contains a large proportion of magnesium sulphate, is also usually called sulphate of potash in this country. It contains about 50 per cent of potassium sulphate, corresponding to about 27 per cent of pure potash, and is now little used in Britain.

Sulphate of potash is the least extensively used of the potash manures. Muriate of potash, potash manure salts, and kainite, all of which contain their potash mainly in the form of chloride, are all far more extensively used.

Most mixed manures contain one of these and not sulphate of potash.

Sulphate of potash is preferred to any of the other potash manures for certain purposes, such as the manuring of potatoes and tobacco. With potatoes it gives tubers of better quality than are given by a manure containing its potash in the form of chloride.

Sulphate of potash is the dearest of the potash manures per unit of potash. This is because it costs rather more to manufacture this salt than it does to manufacture muriate of potash or potash manure salt (see MURIATE OF POTASH). Except in the cases mentioned, therefore, it is more economical to use one of the other potash manures in preference to sulphate of potash. So far as weight of crop goes, even in the case of potatoes, muriate of potash appears to give quite as good a result as the sulphate. See also art. POTASH MANURES. [J. H.]

Sulphur is a non-metallic element occurring in the free state in nature, chiefly in volcanic regions. In Italy and Sicily large quantities of native sulphur are found, and these form the principal European source. Large deposits also occur in Transylvania, China, Iceland, India, California, and the Yellowstone district of the Rocky Mountains. The sulphur of commerce is of two kinds, namely, flowers of sulphur and lump, stick, or roll sulphur, commonly called brimstone. The chief sources of sulphur are native sulphur, and sulphides of the metallic elements. The principal uses of sulphur are for the manufacture of sulphuric acid, as a fungicide, as a constituent of washes for eradicating insect pests, for vulcanizing rubber, and for bleaching and disinfecting purposes. As milk of sulphur it possesses medicinal properties. Sulphur is an essential element in plant and animal nutrition. [R. A. B.]

Sulphur Compounds have played an important part in the development of many technical and other industries. When burnt in air, sulphur forms the important compound sulphur dioxide. This gas in presence of moisture bleaches vegetable colouring matters, and for this reason is used extensively in the bleaching of straw, silk, wool, &c. It is one of the most powerful disinfectants, and is extensively used for that purpose. It dissolves in water, forming sulphurous acid, which forms salts called sulphites. The alkaline salts of this acid are employed for the preservation of some tinned and potted foods. Perhaps the most extensive use of sulphur dioxide is for the preparation of sulphuric acid. Sulphurous and sulphuric are the two important acids of sulphur. Sodium hyposulphite, a salt of sulphurous acid, is of importance as a fixer in photography. The salts of sulphuric acid, called sulphates or vitriols, are of considerable commercial importance; some of the principal being—copper sulphate or blue vitriol or bluestone, iron sulphate or green vitriol or copperas, and zinc sulphate or white vitriol. Other sulphates of value are gypsum or calcium sulphate, heavy spar or barium sulphate, and Glauber salts or sodium sulphate, and the alums. With hydrogen, sulphur forms the evil-smelling gas sulphuretted hydrogen. Many ores occur as compounds of this gas; some of the principal being—galena, or lead sulphide, zinc blende or zinc sulphide, pyrites or iron sulphide, stibnite or antimony sulphide, and cinnabar or mercury sulphide, &c. With the element carbon, sulphur forms the important liquid carbon disulphide, used for extracting oils, perfumes, &c. Sulphur is also a constituent of an important class of organic compounds called proteins, and of many other compounds found in plants and animals. [R. A. B.]

Sulphuric Acid (Oil of Vitriol, or Vitriolic Acid), H_2SO_4, is probably the most important of all chemicals, because of its extensive use in a very large number of manufacturing operations. Enormous quantities of this acid are annually produced, and its manufacture forms an important chemical industry. It is prepared commercially by passing the following gases, sulphur dioxide, nitrogen peroxide, and steam, into a large leaden chamber, where they react with each other, forming sulphuric acid, as shown in the following equation:—

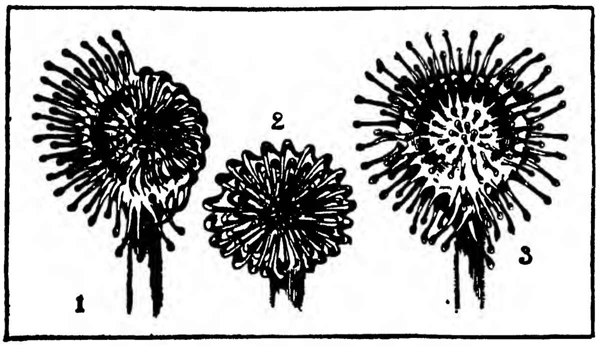
$$SO_2 + NO_2 + H_2O = H_2SO_4 + NO.$$

Pure sulphuric acid is a colourless, odourless, oily liquid and very heavy at 0° C.; it has a specific gravity of 1·854. The commercial acid is generally coloured greyish, due to the presence of traces of organic matter. It has a very powerful attraction for water, and when left exposed, absorbs moisture from the atmosphere with readiness. For this reason it forms one of the most powerful desiccating agents, and it is commonly used for drying those gases upon which it has no chemical action. It withdraws the elements of water when poured on to sugar, starch, textile fabrics, &c., with the result that the material is corroded and blackens or chars. When water is added to the strong acid it gets very hot, and when heated strongly it decomposes, giving off fumes of sulphur dioxide. It reacts on metals, forming sulphates and evolving hydrogen under some circumstances, and sulphur dioxide in others. It is used in the manufacture of superphosphate of lime, parchment paper, acids, in chemical analysis, and for a vast number of other purposes. [R. A. B.]

Sunday is in England a *dies non*, *i.e.* one on which no legal business can be transacted. Thus meetings of public bodies cannot be held on this day, nor may processes be served or persons arrested except for crime. A contract entered into on Sunday is void. Notice to quit premises leased may be served on a Sunday. In Scotland, however, while no judicial act can legally be performed or diligence executed on a Sunday, private contracts are not invalidated although they have been entered into on that day. A number of old Acts both in England and Scotland make provision against work of any sort, except those of necessity or mercy, being done on a Sunday, but these Acts are largely in desuetude. The opening of licensing premises is specially provided for by the licensing statutes. It is illegal to kill game on Sunday in England, but in Scotland there is no provision against the killing of game on any particular day. If the last day of grace for

payment of a bill falls on a Sunday, the bill is due on the preceding business day; where the last day of grace is a bank holiday, or is a Sunday, and the second day of grace is a bank holiday, the bill is due and payable on the succeeding business day. [D. B.]

Sundew (Drosera) is the common name for a genus of insectivorous plants of which three species are British. They inhabit moorland and bog. Their favourite haunt is the bog moss (Sphagnum), into which they strike their scanty and shallow roots. Flowering occurs in July and August. The interesting thing about these Sundews is that while like other green plants they contain chlorophyll and manufacture food from simple inorganic substances, they also supplement this by catching insects and feeding on their bodies. The upper surface of each leafblade is covered with about 200 hairlike outgrowths called tentacles or digestive glands. These tentacles are coloured red, and from their apices round blobs of digestive juice are exuded which, when the sun shines, look like drops of dew. Should an insect alight on such a leaf, it is entangled in the sticky juice, the tentacles begin to curve and move in the direction of the insect so as to envelop it completely, and the whole leaf is ultimately closed up. The digestive process begins, the digested food is absorbed, and then converted into the living substance of the Sundew plant. After a time the leaf opens up, and is ready to entrap another insect. On a single Sundew leaf, the skeletons of a dozen insects may often be counted. Compare art. BUTTERWORT as regards similar habit of that plant. [A. N. M'A.]



Tentacles on Leaf of Sundew (magnified)

1, Leaf with half its tentacles over a captured insect. 2, Leaf with all its tentacles curved inwards. 3, Leaf with all its tentacles extended.

Sunflower Cake.—This cake is manufactured by pressing the seeds of *Helianthus annuus*, a plant belonging to the nat. ord. Compositæ, a native of tropical America, but generally grown throughout Europe and Asia. The seeds are largely used by themselves as a food for poultry. On the Continent the cake is employed to a considerable extent as a food for cattle, but does not come much to England. It is also made use of as a manure. The composition of the seeds and the cake is represented by the following analysis:—

	Sunflower Seeds.	Sunflower Cake.
Moisture	10·97	7·10
Oil	24·50	7·43
[1] Albuminous compounds ...	15·37	19·01
Soluble carbohydrates, &c. ...	16·99	28·93
Woody fibre	28·63	30·03
Mineral matter (ash)	3·54	7·50
	100·00	100·00
[1] Containing nitrogen	2·46	3·04

[J. A. V.]

Sunstroke.—It is popularly supposed that the direct rays of the sun on the back of the head induces the condition which passes by the name given it here; but heat stroke is a better term for it, as the greater number of cases occur in the sunless holds of horse ships and the close stables of contractors. Out of doors the heat is more or less tempered by the wind, and seldom indeed are animals struck in the field, although heat apoplexy or sunstroke is common enough in the streets of great cities with high houses like New York, but here the conditions approximate to those we have already described as most provocative of the malady. The symptoms are those of apoplexy: an intense drowsiness, in which the animal presently becomes quite unconscious and sinks to the ground, more often falls as if struck suddenly. Writers have spoken of it as of ordinary apoplexy, in which blood escapes from ruptured vessels, or described them as so engorged as to produce this comatose condition. If it were so, the usual prolonged paralysis so well known in the human subject would be the general sequel. If the writer asserts that the contrary is the case, it is because he has seen something like a hundred horses down and incapable from heat stroke on the lower decks of transports during the Boer war, and hardly ever failed to recover them so long as cold sea water could be poured over them with the hose. Serous apoplexy, with exudation of the watery portion of the blood, it probably is, in those cases which recover in a few hours. The treatment has been disputed by those who have had no experience of heat apoplexy; but the administration of half-ounce doses of carbonate of ammonia, with a dram or two of ginger, the cold douche, and fresh air, has proved so successful with the veterinary officers that it may be recommended with considerable confidence. [H. L.]

Superphosphate.—The name superphosphate, or superphosphate of lime, is applied to manures obtained by treating substances containing tricalcium phosphate ($Ca_3P_2O_8$) with sulphuric acid. The term is now almost entirely confined to the product obtained from natural minerals—phosphorites, apatites, &c., though a little superphosphate is still made from bone ash and bone black. The manure made by dissolving bone meal with sulphuric acid is called dissolved or vitriolated bone. Similarly, man-

ure made by dissolving guano with acid is generally known as dissolved guano. At one time such substances were also known as superphosphates. The manufacture of dissolved manures began soon after 1840. The great chemist Liebig suggested in that year that bones might be made more active as manure by breaking them up with sulphuric acid. Lawes, then a very young man, had arrived at the same conclusion independently, and was already privately manufacturing small quantities of dissolved manures, both from bones and mineral phosphates, for experimental purposes. In 1842 he took out a patent for the manufacture of superphosphate, and began the manufacture on a commercial scale at Deptford. At first he used bone ash, but in 1845 he began to use coprolites on a large scale. (See COPROLITES.) This was the beginning of what is now the greatest of all the manure industries. The manufacture of superphosphate is now carried on in all parts of the world, and more sulphuric acid is used in it than in any other industry. There is a greater weight of superphosphate used than of any other artificial manure; the whole annual output amounts to many millions of tons, of which about 800,000 are made in the United Kingdom.

The object of manufacturing superphosphate is to obtain the phosphate in a form in which it is soluble in water. The mineral phosphates used contain the insoluble tribasic phosphate of lime ($Ca_3(PO_4)_2$). If this is treated with excess of sulphuric acid it yields phosphoric acid and calcium sulphate:—

$$Ca_3(PO_4)_2 + 3H_2SO_4 = 2H_3PO_4 + 3CaSO_4.$$

In this way all the phosphoric acid can be rendered soluble, but the product is in a liquid and very acid condition not fit for use as a manure.

There are two phosphates of lime intermediate between the tribasic phosphate and phosphoric acid. These are the dibasic phosphate or dicalcium phosphate, $CaHPO_4$, and the monobasic phosphate or monocalcium phosphate, $CaH_4(PO_4)_2$. Of these the dibasic phosphate is insoluble in water and the monobasic phosphate soluble in water. The object of the manufacturer is as far as possible to prepare the monobasic phosphate. By using a suitable proportion of sulphuric acid he can turn a large proportion of the phosphate into the soluble monobasic form, according to the equation:—

$$Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4.$$

Even if pure tricalcium phosphate is used, this theoretical reaction is never completely attained, but on the one hand a small proportion of phosphate remains insoluble, and on the other hand a certain proportion of free phosphoric acid is formed. The phosphates of commerce from which superphosphate is prepared are by no means pure, and the presence of the impurities increases the complication of the reaction. The manufacturer has to steer between two dangers. If too much acid is used the superphosphate is obtained in moist sticky condition, while if too little is used the material is not well dissolved and contains too much phosphate not soluble in water. When a good class of mineral phosphate is used, the skilful manufacturer can obtain a product containing not more than 2 per cent of phosphate not soluble in water, and yet in good dry condition.

In manufacturing superphosphate the acid is not used pure, but is diluted with a considerable proportion of water. This diluted acid in calculated quantity is mixed with the finely-ground phosphate. The mixture is at first in a very wet condition, like a thin mortar or cement. On standing, it gradually dries up. This is because the water also enters into the reaction and combines with the calcium sulphate and soluble phosphate formed, in accordance with the equation:—

$$Ca_3(PO_4)_2 + 2H_2SO_4 + 5H_2O = CaH_4(PO_4)_2 \cdot H_2O + 2CaSO_4 \cdot 2H_2O.$$

The sulphate of lime combines with water to form gypsum, and each molecule of soluble phosphate also combines with a molecule of water. To carry out this theoretical reaction each 100 parts of tricalcium phosphate would require to be mixed with 92·2 parts of the mixture of sulphuric acid and water, and would yield 192·2 parts of superphosphate.

The mineral phosphates used in practice are by no means pure tricalcium phosphate. The coprolites used in the early days of the manufacture were very impure (see COPROLITES), and even the better-grade rocks used at the present day always contain various impurities, such as carbonate of lime, fluoride and chloride of lime, siliceous matter, and small quantities of compounds of iron and alumina. (See MINERAL PHOSPHATES.) The chief mineral phosphates at present in use in this country are those of Florida and those of North Africa, such as Algerian and Tunis phosphates. These always contain carbonate of lime, sometimes, as in North African phosphates, in considerable proportion. They also always contain fluoride of lime. The sulphuric acid acts on the carbonate and fluoride of lime and breaks them up, forming sulphate of lime, and liberating carbon dioxide gas and hydrofluoric acid gas. During the preparation of superphosphate there is always a strong effervescence, with a copious liberation of gases. Hydrofluoric acid gas is a poisonous and extremely corrosive gas, and therefore special means have to be adopted during the manufacture for drawing off the gases and absorbing the hydrofluoric acid gas.

The presence of compounds of iron and alumina in the mineral phosphate used is objectionable. They combine with acid, and render it difficult to get the material well dissolved without using such an excess of acid that the condition of the superphosphate is not good. They also cause the phosphate to 'revert', or to lose solubility to a certain extent when it is stored. The phosphatic rocks now used in this country contain very little iron and alumina, whereas those formerly used contained considerable percentages. The principal constituent of superphosphate is not phosphate but gypsum, of which a large proportion is necessarily produced by the reactions which take place in the manufacture. The greater the proportion of car-

bonate and fluoride of lime in the original phosphatic rock, the greater is the amount of acid required, and the greater will be the proportion of gypsum in the finished superphosphate. The addition of so much acid and water, which is found in the finished article mainly in the form of gypsum, necessarily reduces the percentage of phosphate. Thus, if the mineral phosphate used contained 80 per cent of phosphate, the resulting superphosphate will not contain much more than 40 per cent, and may contain less. Roughly speaking, the superphosphate contains about half the percentage of phosphate which was contained in the mineral phosphate used, and each ton of mineral phosphate yields about two tons of superphosphate.

It is the custom in this country, and that custom has been recognized by law in the Fertilizers and Feedingstuffs Act, to make all statements of percentages of phosphate in manures in terms of the tribasic phosphate of lime, $Ca_3P_2O_8$, whether the phosphate is actually present in this form or not. Thus, when it is stated that a sample of superphosphate contains 40 per cent of soluble phosphate, the statement does not mean that there is actually 40 per cent of the soluble, monobasic phosphate of lime present. There is only about 30 per cent present. It means that if the soluble phosphate is calculated as if it were tricalcium phosphate the result will be 40 per cent. This is sometimes explained by stating that it is 'the tricalcium phosphate which has been made soluble' which is calculated. That also, however, is an inaccurate statement. This method of stating soluble phosphate is really an unfortunate trade custom which has now become thoroughly established, and is recognized as the legal method of statement. See art. PHOSPHATIC MANURES.

The amount of soluble phosphate present in the ordinary superphosphates of commerce varies from about 25 to about 40 per cent. It is seldom that a superphosphate is met with containing less than 25 per cent of soluble phosphate or more than 40 per cent, but all grades between these two figures are met with. In the early days of the manufacture of mineral superphosphates, those containing 25 or 26 per cent of soluble phosphate became established as the standard quality. With the impure mineral phosphates then in use, this was a convenient grade to manufacture. Nowadays, with high-grade Florida and North African phosphates there is little reason for the manufacture of this grade of superphosphate, but as it still continues in large demand among farmers it is still very largely made. Indeed, a certain amount of low-grade phosphate is used for mixing with and diluting better-class rock merely to meet this demand. The high-grade superphosphates containing 30 to 40 per cent of soluble phosphate are, in proportion to the phosphate they contain, cheaper to manufacture than the 26-per-cent quality. It is therefore usual to find that the low-grade 26-per-cent superphosphates cost a little more per unit of phosphate than a superphosphate containing 30 to 40 per cent of soluble phosphate.

In valuing superphosphate, only the soluble phosphate is taken into account. No value is placed upon the small amount of insoluble phosphate present. It is to the advantage of the manufacturer, therefore, to have as large a proportion as possible of the phosphate soluble. The soluble phosphate of superphosphate costs a great deal more per unit than insoluble phosphate in mineral phosphate, bones, or other manures. This is necessarily so, as the acid required to manufacture the soluble phosphate makes up a large part of the cost. A unit of insoluble phosphate in the form of finely ground mineral phosphate can be bought for about 9*d.*, but a unit of soluble phosphate in the form of superphosphate costs about 1*s.* 10*d.*

The special value of superphosphate as a manure is due to the fact that the phosphate is soluble in water, and therefore when used as manure is washed into the soil in solution by the rain. In this way it gets thoroughly distributed through the surface soil. This leads to better distribution than can be brought about by mixing an insoluble powdered material with the soil.

The soluble phosphate when washed into the soil is quickly reverted into the insoluble state by the carbonate of lime and the compounds of iron and alumina present in the soil. This is important, as it ensures that the phosphate will not be washed out of the soil and lost in the drainage. The advantage of using soluble phosphate is one of distribution only. The phosphate itself is quickly turned into an insoluble form, and remains in the soil as an insoluble phosphate of lime or as a phosphate of iron or of alumina. [J. H.]

Support.—The right to support for land from the adjacent or subjacent strata is, in its broadest form, a natural right as contrasted with such conventional rights as easements (or servitudes, as they are known in Scotland), but the right to support may be acquired as an easement. The necessity for some such safeguard against the indiscriminate use of his property by a neighbouring proprietor is clear. But for this, an adjoining owner might so excavate the adjacent or subjacent soil as to cause his neighbour's land to subside and so suffer great depreciation. Such subsidence may be caused either by excavating the ground adjoining up to or near the boundary, thus withdrawing the adjacent support, or, where the ownership of the surface and the underlying minerals has been divided, by working the minerals so as to withdraw the subjacent support. In either case the principles of the law applicable are the same, and the same principles apply to the rights of higher and lower mine-owners.

The right may arise either (1) where the surface is unencumbered with buildings or other artificial structures, or (2) where the surface is so encumbered.

(1) *Where the surface is unencumbered with buildings or other artificial structures.*

The right to support in this case being a natural right, depends for its existence on no agreement actual or implied—'it stands on natural justice, and is essential to the protection and enjoyment of property in the soil'.

The right is absolute, and consequently, in certain cases, may altogether prevent the working of the minerals where they belong to a different owner from that of the surface. In such a case, if the work cannot be carried on without causing subsidence to the neighbouring land, the minerals must just be left untouched. The only remedy is to arrange with the adjoining proprietor.

But, on the other hand, it must be noted that a proprietor is only entitled to support for the land in its natural state, and cannot increase the natural burden resting on his neighbour. If therefore a proprietor excavates his own ground near to his boundary, he is not entitled to complain of the excavation of his neighbour, unless he can show clearly that his own working did not contribute to the subsequent subsidence.

The right is merely to such support as will permit of the enjoyment of the surface of the land. Consequently there is no absolute right to demand that the adjacent or subjacent soil be kept in its natural state. A proprietor has no right to dictate the particular means whereby the ground is to be supported, and so long as no damage ensues he has no right to complain of his neighbour's use of his own property.

The natural right of support may be lost through the terms of the deed whereby the severance of the surface tenement from the underlying tenement is effected, by subsequent agreement or by the operation of an Act of Parliament. Prima facie the right to support is always supposed to subsist, and if the contrary is affirmed the onus of proof lies on the party so asserting.

(2). *Where the surface is encumbered by artificial structures.*

The principles of law which apply to this right are totally different from those which apply to the right when land is in its natural condition. It is one of the principles of law that the natural burden inherent on the proprietor cannot be increased, and consequently the right to support for land which has been burdened is no longer a natural right, but a conventional obligation. That is to say, the rights of parties must stand upon contract, express or implied. If, however, the right to the support be once validly acquired, the rules which regulate it are similar to those which have already been referred to as governing the natural right of support.

It is to be noted, however, that although a proprietor has put buildings or other artificial structures on the ground, or has excavated his ground, he does not by this action lose his natural right to support for the ground. The natural right is merely suspended for the time being, and remains in force notwithstanding building on the ground or excavating below it. While, therefore, it is the case that the adjoining proprietor is not liable to support ground encumbered by buildings or other artificial structures, and is not liable for damages caused by subsidence, if, but for the building or excavation, it would not have occurred, yet, on the other hand, the natural right still remains if it can be shown that the subsidence would have occurred whether or not buildings or other artificial structures had been put upon the ground, or whether or not the ground had been excavated. Then the adjoining proprietor through whose acts the subsidence has been caused is still liable in damages for having withdrawn the support to which the adjoining proprietor was entitled as a natural right.

The right of support for land encumbered by artificial structures may be acquired either by grant, express or implied, or by prescription.

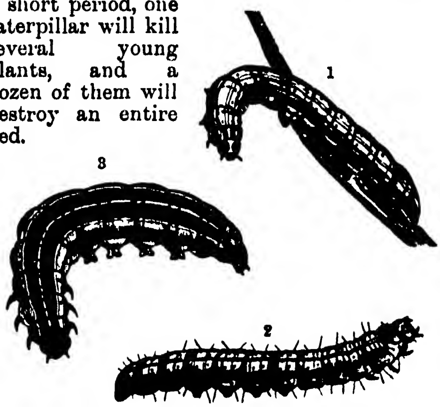
The right of support for land encumbered with artificial structures, if acquired, will extend only to the express terms of the grant, or to the uses which may be held to have been fairly in the contemplation of the parties at the time when the servitude was created. Therefore the burden must not be materially increased without the consent, express or implied, of the owner of the servient tenement. Moreover, even where the right of support does exist, it does not necessarily follow that an action will lie although the buildings are damaged. If it can be shown that the state of the building or its faulty construction have materially contributed to the damage complained of, the owner cannot recover.

The acquired right of support to land not in its natural state, *i.e.* either excavated or encumbered with buildings, may be lost. This, however, can only be by express renunciation or Act of Parliament, for as in the case of the natural right, so in the case of the acquired right, prescription will not infer abandonment of the right to support, but at most abandonment of the right to claim reparation for past damage. The acquisition of the right by prescription may, however, be defeated by interruption of the running of the prescription by some act on the part of the servient owner—*e.g.* the removal of support.

In the case of lands taken compulsorily, *e.g.* under the Railway Clauses Act or the Water Works Clauses Act, the minerals are by Statute expressly reserved to the proprietor of the ground, and there is no implied right of support although the ground has been expressly taken for the purpose of making a railway, &c. In lieu of this right the promoters of the company have power either to purchase the minerals or to prevent their being worked by paying compensation. Failing their either purchasing or making compensation, the owner may work the minerals even though he may thereby bring down the railway. Nor will he be liable in damages unless his mode of working has been improper. [D. B.]

Surface Grubs are the caterpillars of several species of night-flying moths, as *Agrotis segetum* and *A. exclamationis* and *Triphæna pronuba*, which lie concealed in the soil, where they eat through the roots of plants, killing at once the young ones, coming forth only at night to feed upon the foliage. As descriptions of the moths and caterpillars will be found under the respective species, it only remains to detail their economy. The surface grubs, when full grown, are, most of them, as large as a goose-quill; an inch or two long, tough, smooth, and somewhat

shining. Those produced from the eggs of the Heart-and-Dart Moth (*Agrotis exclamationis*) and of the Common Dart Moth (*A. segetum*)—both figured in art. Agrotis—sometimes commit sad devastation in turnip and young mangold fields, and even potatoes, when just appearing above-ground, do not escape them; they are also very destructive in the cornfield and in the garden. They are in existence most of the year, and in some seasons are abundant and full-grown from the beginning of June till the approach of winter. In summer they will often eat off the crowns of the turnips, and in autumn groups of them are found eating holes in the bulbs just at the surface. In the garden they clear off the cabbage tribes and lettuces with astonishing rapidity, by eating through the taproot a little below the surface, and at night they come forth and draw the detached leaves into their burrows. As soon as a plant droops, if the earth be carefully removed, the surface grub will be found just beneath the surface, and close to the root; but if left for a night, the culprit comes forth, travels with great speed to a neighbouring plant to accomplish the same mischief, and thus, in a short period, one caterpillar will kill several young plants, and a dozen of them will destroy an entire bed.



1, Caterpillar of *Agrotis segetum*. 2, Caterpillar of *Agrotis exclamationis*. 3, Caterpillar of *Triphæna pronuba*

The larvæ of the Great Yellow Underwing Moth (*Triphæna pronuba*) often accompany the foregoing, and are similar in their economy, but they are larger and less numerous; they live through the winter, and can withstand very severe weather.

Prevention and treatment depend on the crop attacked. Turnips and swedes that are attacked should be fed off early by sheep. Frequent stirring with hoes of land in drills (turnips, swedes, mangolds, &c.) does much good, as many larvæ are killed. Applications of soot are most beneficial, so also is kainit. Potatoes should be well earthed up early in the season if attack is feared. The use of poisoned baits is well worth while. These may be made by dipping clover or lucerne in a strong arsenical wash and laying patches about near the infested crops. The larvæ feed on this readily and are poisoned, care being taken, of course, that live stock do not get at the 'baits', which must be protected.

Hand-picking is the most successful mode of diminishing these pests, and the numbers that have been collected by women and children in some seasons is astonishing. But this, owing to the cost, can only be done in gardens and market gardens. Rooks, starlings, plovers, gulls, &c., do good service; and it is most essential to keep the land clean at all times, as many of these surface grubs will feed also on Groundsel, Shepherd's-purse, the roots of grasses, and other weeds. [J. C.] [F. V. T.]

Surveying.—The general problems which present themselves in agricultural and estate surveying are: (1) The production of a plan of some given piece of land on which must be correctly delineated its boundaries and its various subdivisions; (2) the determination of the area of the piece of land dealt with, and the areas of its subdivisions under various crops, pasture, &c.; (3) the laying out of the land to meet given conditions and in sections of given area.

Simple Chain Surveys.—In a large number of the cases in ordinary agricultural practice the work may be carried out with the aid of a few simple instruments, viz. a surveyor's chain and arrows, a measuring tape, ranging rods or poles, a cross staff, or an optical square. Before giving an example of an actual survey it will be advisable to discuss these simple instruments and their particular uses.

The Chain.—The chain used in land surveying in this country is the Gunter chain (fig. 1),

Fig. 1.—Surveying Chain

66 ft. in length, divided into 100 equal parts called links. Its great advantages are its relations to the standard units of length and area.

Length of chain = 66 ft.
Now 1 mile = 8 fur. = 1760 yd. = 5280 ft.
∴ number of chains to 1 mile = 80,
and number of chains to 1 fur. = 10.
Again, 1 ac. = 4840 sq. yd.,
∴ 1 ac. = 10 sq. chains.

These relations simplify very much the numerical work involved in the reduction of the field measurements.

The chain is made of either steel or iron wire, and is provided with brass handles with swivel attachments. The details of the chain are shown in fig. 2. It will be noted that each tenth link is denoted by a brass marker or 'teller' indicating its position from either end of the chain. Fig. 3 is a general outline of the chain showing the brass markers in position. It will be observed that a marker with four points indicates either 40 or 60 links, one with three points indicates either 30 or 70 links, the mid or 50-link

point being indicated by a circular marker. The markers are arranged in this manner in order that the chain may be read from either end, and every care must therefore be taken in reading the chain in the field not to confuse the 40- with the 60-link marker or the 30 with the 70. If the position of the 50-link marker is first observed, the risk of mistakes will practically

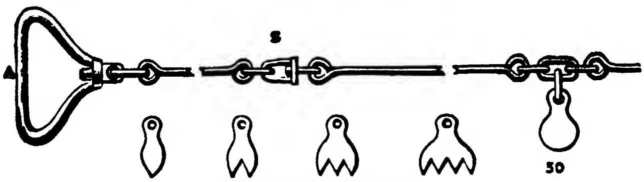


Fig. 2.—Detail of Chain

be eliminated. In all work where accuracy is required the chain should be tested at least once every day, as with constant use the chain becomes inaccurate; some of the long links may become bent, or the small rings may be elongated by constant pulling. A steel tape (made of a nickel-steel alloy, *invar*) should be kept exclusively for the purpose of testing the

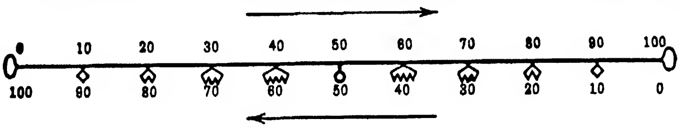


Fig. 3

chain. The errors which may arise from the use of chains of incorrect length are often entirely neglected in ordinary practice. But in the case of comparatively large areas the errors are too serious to be neglected, as will be shown.

Correction for Error in Chain Length.—Suppose the chain to be too long and the error to be 1 link, then actual length of chain = 101 links. Suppose a line is measured with this chain in the field and found to be 12·0 chains. Then the true length of this line would be 12·0 × 1·01 = 12·12 chains. In a similar manner, suppose the chain to be 1 link too short, then the actual length of chain = 99 links = ·99 chain; and if the measured length in the field is found to be 15 chains, say, then the true length of the line = 15 × ·99 = 14·85 chains.

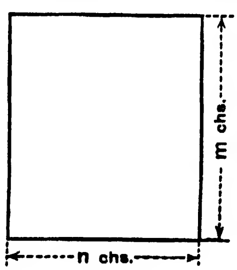


Fig. 4

The lines of the survey may be all corrected in this manner before plotting, and the correct area then found. Or the survey may be plotted from the readings in the field, the average error of the chain determined, and the area finally corrected.

Thus, suppose ABCD to represent the survey, and let the chain be too long. Let x = error.

Therefore actual length of chain = $(1 + x)$ chains.

Area from field measurements: $A = mn$ sq. chains.

True area $A_1 = mn\,(1 + x)^2$, which, since x is a small quantity, may be written $A_1 = mn\,(1 + 2x)$.

Therefore $A_1 = A\,(1 + 2x)$. Similarly, if the chain is too short, true area $A_1 = A\,(1 - 2x)$.

In a certain survey the error in a chain which was too long was 1·5 link, and the area found from the plan plotted from the field book 860 ac.

Here the error is 1·5 link = 0·015 chain. Therefore true area $A_1 = 860\,(1 + 2 \times 0{\cdot}015) = 885{\cdot}8$ ac.

The error in area is therefore 25·8 ac., a sufficiently serious matter if it is a question of the purchase, sale, or valuation of land.

Use of the Chain.—In using the chain two men are required, termed respectively the 'leader' and the 'follower', the duties of the two men being briefly as follows:—

The follower takes one end of the chain and holds it against the pole at the starting-point; the leader, taking the other end of the chain and 10 arrows, walks on towards the pole marking the end of the line to be measured; he is placed in correct alignment by the follower. The leader holds the end of the chain and an arrow in his right hand as shown in fig. 5, and when finally aligned drives the arrow into the ground, and again proceeds to the distant station point. The follower picks up the arrows as he comes to them, and therefore by counting the arrows which he has in his hand he can tell the length of line chained to the particular point. If the line is not an exact number of chains, the additional links are read off on the chain. If the ten arrows have been used the leader drags the chain on, laying down an eleventh chain, and marking the end of the chain; the follower then picks up the tenth arrow, walks up to the leader, and gives him again the ten arrows. The leader then drives an arrow into the ground at his end of the chain, and they proceed as before.

Fig. 5.—Chain Leader

Offsets **are generally measurements taken at right angles to the main survey line to points of the boundaries, buildings, &c. They are most conveniently measured by means of an ordinary linen measuring tape.**

Offsets to Buildings, Corner of Fields, Intersection of Hedges.—The position of a building should be fixed by means of inclined offsets to at least two corners; the corner of the building being thus absolutely fixed by the vertex of a triangle; the plan of the building being afterwards obtained by taping around its base. Similarly the corners of fields, intersection of hedges, &c., may be accurately fixed by means of intersecting inclined offsets.

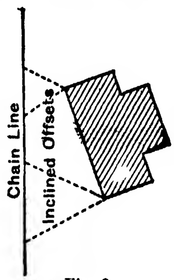


Fig. 6

The Field Book.—The form of field book which will be found most convenient is one having a central column about ¾ in. wide. This column represents the chain, and in it are entered the chain readings. The entries are commenced from the bottom of the page, and also from the end of the book. The surveyor begins his work facing the distant station, and sketches in his field book the boundaries as they may occur on either side of the chain line. No attempt should be

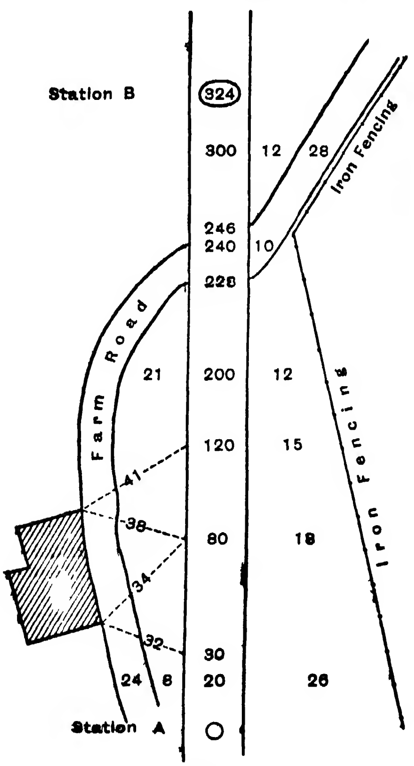


Fig 7

made to draw these to scale in the field book; and further, the surveyor should never cramp his lines or sketches, as this often leads to hopeless confusion and error when the work of plotting has to be carried out. Since the central column represents the chain it is supposed to have no width; therefore if a line such as a fence crosses the road obliquely it cuts the central column lines at points exactly opposite each other. Station points may be denoted by a circle O.

A specimen page field book is shown which will elucidate some of the points discussed.

The Cross Staff and Optical Square.—These may be used for setting out right angles in the field when great accuracy is not required. A simple cross staff giving quite good results may be made from a piece of hard wood $1\frac{1}{4}$ in. thick, cut very accurately to a square of 12 in. side; saw-cuts about $\frac{1}{16}$ in. wide are made along the diagonals, giving us two lines of sight at an angle of 90 degrees. A block 1 in. thick and 3 in. wide is screwed to the back; in this is

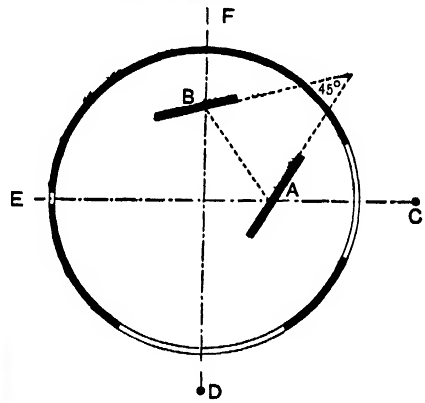


Fig. 8

bored a hole to receive one end of an iron-shod pole about 3 ft. high. The pole is driven into the ground at the point through which the lines at right angles shall pass, these lines being now easily ranged by means of the saw-cut sights.

The optical square (fig. 8) consists of a brass box containing two mirrors, the planes of the mirrors being inclined to each other at an angle of 45 degrees. The upper half of mirror A is silvered, the lower half of A is plain glass; the mirror B is completely silvered. In using the instrument we observe the pole C by direct vision, and then move an assistant about with pole D until the reflected image of D coincides with the direct vision of pole C, the lines CE and DF are now at right angles.

SELECTION OF STATION POINTS.—*Triangulation.*—In all surveys, of whatever dimensions, a careful selection of the main station points well repays the additional preliminary labour involved. As a general rule the main survey lines should run as close as possible to the boundaries of the property under survey, thus keeping the length of the offsets within the smallest possible limits. Again, the station points should be so chosen that the survey lines form a series of well-conditioned triangles. In the case of chain surveying the triangulation is absolutely necessary throughout, in order that

we may be able to plot the survey. Thus, suppose ABCDE (fig. 9) to be the boundary survey lines of a piece of land. The knowledge of the lengths of the sides AB, BC, &c., will not be sufficient to enable us to plot the figure. But if we join AC, CE, then the figure will be split up into three triangles, and the lengths of the three sides being known, the triangles can be

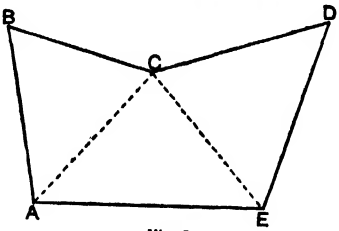


Fig. 9

accurately plotted. The main survey lines having been decided on, and the station points marked by poles, the chaining may be proceeded with, offsets being taken where necessary and booked in the manner already explained.

The ordinary survey plan is the projection on a horizontal plane of the land surveyed. Hence

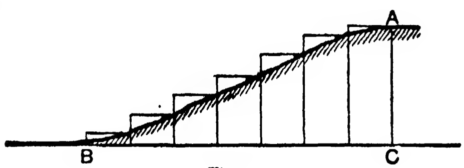


Fig. 10

in dealing with hilly country we must adopt some method of determining the horizontal projection. This may be done by stepping with the chain. In this method a portion only—say 50 links—of the chain is used. Thus, suppose the slope AB (fig. 10) is being chained; the chain is held horizontal with the 50-link marker at A, the leader plumbing an arrow from his handle,

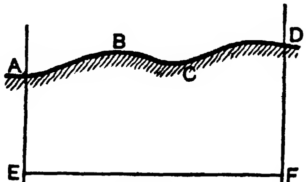


Fig 11

and so on down the hill; then it is obvious that the sum of the horizontal displacements will be equal to BC, the horizontal projection of AB. In the case, however, of the determination of the area of growing crops, &c., the actual surface area is required; and in such cases the chain must be allowed to lie along the surface of the ground. Thus in fig. 11, as in most agricultural surveys, we shall require the actual surface length ABCD, and not the projected length EF.

USE OF ANGLE-MEASURING INSTRUMENTS.—The labour in the field may often be considerably reduced by the use of angle-measuring instruments, the chaining of the diagonal lines being as a general rule completely eliminated. In agricultural and estate surveying the prismatic compass and the theodolite are the two most useful instruments; the prismatic compass is used for the carrying out of small traverse surveys of land or roads, and possesses the advantages of cheapness and portability. For all important work, however, such as the survey

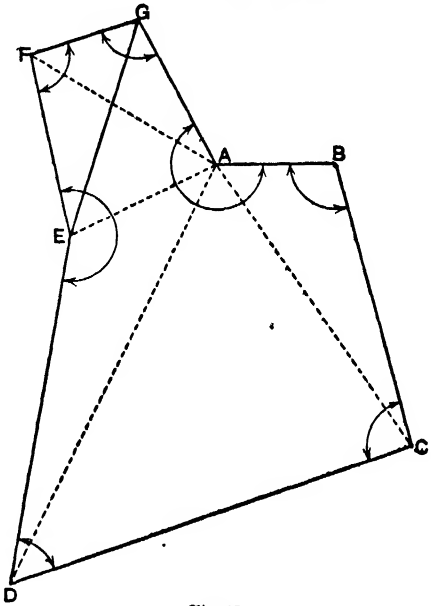


Fig. 12

of large areas, &c., the theodolite is absolutely essential.

Fig. 12 is a simple example of the use of the theodolite in a small survey, and shows clearly the great saving in the work of chaining, since it will not be necessary to chain any diagonal lines such as AC, AD, &c., with the exception of one check line EG.

The main survey lines, AB, BC, &c., must be chained and offsets to the boundaries taken in the usual way.

The internal angles ABC, BCD, &c., may then be measured.

From the data obtained the figure can then be plotted. A simple check may be applied to the angular measurements before leaving the field, since if—

n = number of sides of the figure,
$n.180^\circ$ = the sum of the internal angles + 360°.

Thus, in the example—

$\angle A = 241^\circ\ 40'$, $\angle B = 103^\circ$, $\angle C = 94^\circ\ 20'$,
$\angle D = 62^\circ\ 30'$, $\angle E = 202^\circ\ 30'$, $\angle F = 96^\circ\ 25'$,
$\angle G = 99^\circ\ 35'$, giving a total of 900°.
$n = 7$.

Then $7 \times 180^\circ = 900^\circ + 360^\circ = 1260^\circ$.

With ordinary good work the error should not be more than 5 minutes. [W. A. T.]

Survey Maps. See ORDNANCE SURVEY MAPS.

Sussex Cattle. — Although the Sussex breed of cattle is kept in various parts of Sussex and Kent, and even in Surrey, it is more generally found on South Devon farms, where from time immemorial the oxen have been employed for draught purposes. Oxen are now used much less generally than they were, and it is probable that in course of time they will be entirely superseded by horses. See art. ANIMAL LABOUR.

There is reason to believe that the Sussex breed has a common origin with the Devon. Not only is this belief emphasized by the similarity of colour, but by the resemblance of the Sussex to the larger of the Somerset Devons of fifty years ago. Since then great improvement has been made in both varieties. The Sussex have been gradually improved by selecting stock of a more suitable type for the production of beef instead of, as was formerly the case, for purposes of draught. A century ago, beef was of less importance to the Sussex farmer than work upon the land, and stock were at that time chiefly bred for size and strength. Arthur Young, however, writing at the end of the 18th century, claimed that the Sussex cattle were equal to those of any other breed.

Fifty years later, the Earl of Sheffield spoke of two varieties of the Sussex breed—the smaller, which had been bred to type for centuries, and was then believed to have been derived from the same stock as the Devon; and the larger subvariety, which was slower in its gait, taking a longer time to accomplish its work before the plough, and which displayed but little difference from the Hereford if we except colour, which was then distinctly red. The cattle of the larger type were believed to have been derived from a mixture of the blood of the old Sussex variety, which, owing to the fact that it was fed upon richer pastures than the South Downs afford, reached a larger size; but it could not compare with the smaller type of Sussex, which was almost equal to the horse in speed, drawing heavy loads as much as fifteen miles a day for many days in succession. Lord Sheffield points to the fact that on one occasion a Sussex ox travelled over the four-mile racecourse at Lewes in sixteen minutes. Heifers were sometimes spayed and used for draught purposes; and when, as was often the case, they were harnessed like a horse, they responded to the rein. In some instances the older class of beast, after the completion of its working period, reached considerable weights, frequently exceeding a ton; and although 120 st. was about the average of the beasts exhibited at the earliest Smithfield Shows, a weight of 200 st. was occasionally exceeded. One of the most famous breeders of the time, Mr. Ellman, who occupied a well-known farm near Lewes, described the Sussex as cattle with fine hair and thin skin, horns which were neither long nor short, but rather turning up at the points. He says they were well made in the hind quarters, with broad hips, rump, and sirloin, but a narrow chine; the ribs were rather flat, while the thigh was thin, and the bone not large. The cattle at this period were rather heavy in the fore quarters, and mostly worked from the age of three up to seven years, when they were fed off for the butcher, reaching as much as 100 st. of 14 lb.

Sussex cattle as they are found to-day may almost be described as still embracing two types —those which are bred and fed by breeders of the highest rank, in large part for exhibition and for beef, and which are fed upon the richer pastures of the county and adjoining districts and the larger type of Sussex, which are found in the vicinity of the South Downs, where they are more generally employed as working oxen. Between the Downs which commence at the Devil's Dyke near Brighton and which terminate near Eastbourne are valleys where the true working oxen may be found; and here they are still used for draught purposes up to six or seven years of age, when they are fed off for the butchers in the neighbouring towns.

Many describe the Sussex, as long exhibited at the great English shows, as a large-framed, rather tall, unbroken red, somewhat resembling the Devon in the shade of its colour; but it is much less compact in form and coarser in quality, although during recent years it has been materially improved, being blockier, and more closely resembling the recognized type of a good beef-producing beast. The legs are shorter than they were, the body deeper, and the finer points of the breed distinctly better. As we shall show later on, the steers produce excellent weights at an early age, and, when killed at some two to three years, produce beef of fine quality, especially on the round and loin, while the ribs are by no means to be despised. The cows are not good milkers, no pains having been taken, so far as we are aware, by any of the most famous breeders to produce milking strains, or to make any serious attempt to improve the milking powers of the cows they possess. We have never heard of a real dairy herd of Sussex cows. The milk is inferior for the production of butter, and equally inappropriate to the production of cheese, while the quantity is usually not quite sufficient to feed the calves which the cows produce, although it is the occasional custom to run the cows and the calves together.

The points of the breed are as follows: The head is rather wide, both across the nostrils and the forehead; there is a dewlap of medium size; the breast is wide and prominent; the chine, like the back, straight in good specimens; the loin fairly wide, although in this point the Sussex is behind the Shorthorn and the Hereford; the barrel is well rounded, the ribs being sprung, giving prominence to that portion of the body, and plenty of play for the heart and other vital organs; the legs are straight, of medium length, and the bone fine. We have frequently observed, in examining leading animals at the Smithfield and Royal Shows, that in this particular point there is a definite improvement, the body being nearer the ground as it were, giving the form to the carcass which is so desirable in a butcher's beast. The neck is well formed, clean, and of medium length; the coat covered with hair of fairly good length and

Photo Chas. Reid.

SUSSEX BULL—"APSLEY LIBERTY"

FIRST AT R.A.S.E. SHOW, 1910

Photo Chas. Reid.

SUSSEX COW—"GAIETY GIRL"

FIRST AND CHAMPION, R.A.S.E. SHOWS, 1903 AND 1904

fine, silky quality; the rump, which in the Hereford, the Shorthorn, the Angus, and the Devon is much superior, is gradually improving in form, not sloping so much as in earlier days, but fairly flat, and broader near the setting of the tail than was the case some years ago. We cannot call the Sussex an all-round breed, although it is much approved by those who breed and feed it—a fact which generally applies to the cattle of those particular districts in which pure breeds are kept. It may be described as an excellent butcher's beast and useful for draught purposes; but in these days the latter feature is a *quantité négligeable*, and not a meritorious point, while the inferiority of the cows as milkers places it in the second rank of British stock.

Among the leading breeders of the Sussex are Earl Winterton, the Hon. Ralph Nevill, Mr. C. J. Lucas of Warnham Court, Mr. Ernest Braby of Rudgwick, Mr. Philip Saillard of Crawley, Mr. F. S. W. Cornwallis of Maidstone, Mr. William Winch of Cranbrook, Mr. John Aunger of Rudgwick, Mr. Gerald Ward of Maidstone, Mrs. Montefiore of Crawley, and Mr. Stephen Agate of Horsham.

'The Sussex, as a rule,' writes a well-known breeder, 'are very poor milkers, giving scarcely, if ever, sufficient to rear their own calves, and are worse butter-makers. Their weight, of course, differs according to the system of feeding. A Sussex heifer which I once exhibited, under the age of 4 years, showed a weight of 148 st. of 8 lb. to the stone, and a steer aged 2 years 11 months weighed 196 st. These were specially fattened for exhibition; but, as a rule, steers killed under 3 years, and fattened in the usual way, would scale from 90 to 112 st. They require good loamy soil, and the better the grass the earlier they can be made to reach the butcher. It is a great thing to keep all young stock well from birth, housing warmly, and feeding them liberally with a little linseed cake and cracked corn for weaning time. The steers are used very little for draught purposes.'

The following are the measurements and weights of a few Christmas beasts which took prizes at Islington:—

Heifer, 3 years old: 7 ft. 8 in. by 4 ft. 9 in. = 55 score; live weight, 15 cwt. 1 qr. Heifer, 1 year 11 months old: 7 ft. 7 in. by 4 ft. 8 in. = 52 score; live weight, 14 cwt. 3 qr. Steer, 1 year 11 months old: 7 ft. 4 in. by 4 ft. 4 in. = 46 score; live weight, 12 cwt. 3 qr. At the above show the first-prize steer, 21 months, weighed 11¼ cwt.; the second-prize, 22½ months, 13½ cwt. The first-prize steer, 2 years 11¾ months, weighed 19 cwt.; the second-prize, 2 years 7½ months, 14 cwt. The first-prize steer, 3 years 8½ months, scaled 20¼ cwt.; the second-prize, 3 years 2 months, 14¾ cwt. The first-prize cow, 5 years 8 months, weighed 14 cwt.; the second-prize, 6¾ years, 15¾ cwt.

The heaviest weights for age at Smithfield in 1906 were as follows: Steers under 2 years old, 14 cwt. 1 qr. 25 lb., the age being 1 year 11 months. Steers aged 1 year 11 months, 18 cwt. 1 qr. 7 lb. A heifer aged 2 years 11 months weighed 16 cwt. 2 qr. 8 lb. In 1907 a steer aged 1 year 11 months weighed 13 cwt. 3 qr. 14 lb.; one aged 2 years 11 months weighed 17 cwt. 3 qr. 24 lb.; while a heifer aged 2 years 9 months weighed 16 cwt. 0 qr. 4 lb. In 1908 a steer aged 1 year 11 months weighed 15 cwt. 0 qr. 12 lb.; another aged 2 years 10 months weighed 18 cwt. 0 qr. 26 lb.; while a heifer aged 2 years 10 months weighed 16 cwt. 1 qr. 14 lb.

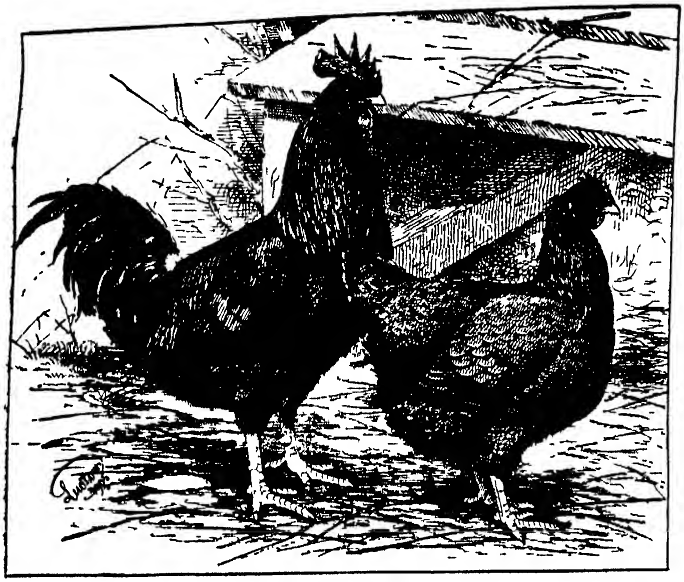
Although the Sussex is so largely grazed upon the Downs, breeders prefer their hair to be long and silky; these generally have a mellower skin and feed better. In the majority of cases it is the custom to work the steers from 3 years old until they are 6 or 7, when they are generally put up to fatten, which they do rapidly. The heifers are seldom bred from until they are 2½ years, producing their first calf at 3 years. In working, all the oxen are kept in good condition, for if too low it is most difficult to bring them back to a fleshy state afterwards.

In some instances the calf is seldom allowed to take all the milk of the cow, which is taken from it all day. It is allowed to suck two of the teats after the milkmaid has drawn the other two, getting in addition to this a small quantity of bran or ground oats, which is left for it in a small trough. At a month old it is usually allowed to run with its dam throughout the day, but is taken from her for the night. A portion of the morning's milk is then taken, and the calf allowed the remainder. This is the general practice of some farmers until the calf is weaned. It is then fed upon cut grass, clover, hay, and bran until it is turned out upon the pasture, when the meal feeding is increased until the following winter, when it takes its place among other yearlings in the yard, and is allowed to browse upon the various products of the farm, getting a certain allowance of roots, meal, and cake each day.

We may sum up in the words of the Secretary of the Sussex Herd Book Society, who remarked that for beef production, for draught purposes, hardiness, early maturity, beautifully fine-grained flesh, and ability to thrive on poor food, few breeds can equal the Sussex. [J. Lo.]

Sussex Fowl.—Intended primarily for production of table chickens, the Sussex is long and deep in body, short in leg, which, together with the feet, are pure-white, in conformity with the colour of the flesh and skin. The comb is single, small in size and fine in texture. These birds are wide at the shoulders, but should not taper much behind, as an even body is desirable. Three colours have been fixed, namely, brown or red, light, and speckled; but the tendency is to divide the first named and to differentiate the brown and the red varieties. In the first the plumage is a chestnut-brown, with black or dark-brown markings. The lights follow the light Brahma, and are least satisfactory. The main colour is white, with black stripes in the hackles, black on the wings and the tail. The speckled are brown and black, with white tips to the feathers, which marking is fairly common in all countries. The birds vary somewhat in size, and are not so big

as Dorkings, generally 7 to 9 lb. when fully grown. The hens are satisfactory layers, but the breed is essentially a table fowl, and its quickness of growth as well as its suitability



Red Sussex Fowl

for fattening makes it desirable to select specially with that object in view. [E. B.]

Swaledale Sheep belong to the Heath group, at the head of which is the Scotch Blackface Mountain breed. It is the survivor of a number of Yorkshire varieties that were classed as Dale sheep, and were peculiarly suited to the districts in which they had been reared for generations. They are similar to the Neasham sheep, named from the market town in which many sheep of the Heath type are sold at the annual September fairs.

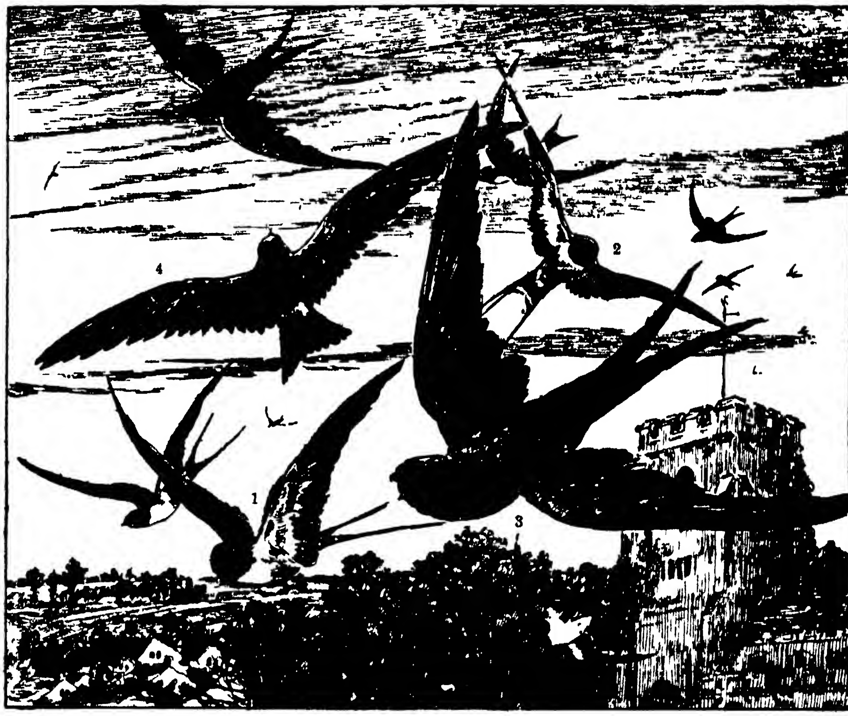
The breed is horned like the Scotch Blackface, their legs are mottled, and their faces are usually dark-grey with mealie noses. They appear to be longer and smaller, owing to a deficiency in wool under the body, especially of the fore quarters; but they are strong-boned, big-bodied, and weigh well. The face is weak for a good Blackface, and the tail is long like that of the Lonk. The quality of fleece is about that of the Lonk, but a little coarser. The breed is increasing in numbers in Yorkshire, and the rams are in demand to mate with ewes of inferior types of the Heath family. The superiority, even in their home localities, of the ewes over ewes of the Scotch Blackface for feeding and breeding purposes is doubtful. In the colour of the face the cross lambs bred by a Wensleydale ram and Swaledale ewes are not so dark and fashionable as the similar cross with a Blackface ewe. This peculiarity puts a premium on the darker-faced progeny of the Blackface by the Wensleydale ram, especially in the case of ewe lambs to be employed in breeding second-cross lambs. An attempt to unite the Scotch Blackface and Swaledale breeds, wi a view to improve the latter, has not prove sufficiently successful to warrant its gener adoption. The progeny were generally heavie sheep, but longer in the necks, tails, and legs tha Blackfaces. Their ungainl appearance would militat against them in the auctio ring, especially in a drag ging market. The fine stapled and shorter woo realized 1*d.* per lb. less be cause of the prevalence o kemps and greys; and the yield was also deficient, ewes averaging 4 lb. against 5 lb given by Blackfaces running on the same mountain pasture. The general management is similar to that common to Mountain breeds. Lambing begins about the middle of April, and ewe hoggets are wintered in the lowlands of Yorkshire at a cost of 6*s.* each. The ewes of the running flock receive no artificial feeding in winter unless during a prolonged snowstorm. Persistent overfeeding of the rams exercises a baneful influence on the constitution of the progeny. Stock rams graze on the hills along with the ewes during summer. [R. W.]

Swallow (*Hirundo rustica*).—Owing to its general appearance and habits, this migrant species is often confused with the House Martin (see MARTINS), but is of larger size, its tail is more deeply forked, the throat is chestnut-brown, not white, and the latter colour is also absent from the legs and rump. The upper side of the body is of a steely black, and the under side white. Arriving in early April and leaving in October, the Swallow is common in most parts of Britain except N. Scotland and W. Ireland. The nest is built under eaves or in similar places, and is distinguished from that of the House Martin by being open at the top. It is made of clay compacted with horsehair and grass, and lined with feathers. The four to six eggs are white speckled with brown (not pure-white as in the House Martin), and two broods are reared in the season. As the food consists entirely of insects caught on the wing, gnats in particular being favoured, the bird is entirely beneficial, and should on no account be persecuted. [J. R. A. D.]

Swamps.—Swamps are marshy lands whose surfaces lie at or about the permanent water level, and whose soils therefore exist in a water-logged and semi-fluid condition. They have been broadly classified into two main divisions, namely, salt-water or marine swamps, and fresh-water swamps. The former type is to be found near the sea level along the coast, generally in indentations of the shore line, or in river deltas, or in the silted-up estuaries of

tidal rivers. (See art. SALT MARSHES.) Swamps of the second group occur inland, are formed in fresh water, and are usually found at elevations much higher than the sea level. The peculiarity of the water-logged soils of these morasses is that they contain a very large proportion of vegetable matter which has accumulated from the growth and partial decay of a local vegetation. The conditions necessary for the formation of a fresh-water swamp are a wet soil-surface and climatic conditions favourable for vegetable growth. Dead organic matter does not accumulate on a dry land surface, but breaks up, by bacterial action, at as fast a rate as it is formed, whereby all the carbon of the vegetable debris is oxidised and returned to the atmosphere in the form of carbonic acid gas. On the other hand, when a soil-surface is wet, complete decay of the organic remains does not take place, and as a result humus matter accumulates to a considerable depth.

Fresh-water swamps may arise from the infilling of shallow lakes, such as were left in the hollows of the glacial boulder clay (see art. BOGS), or they may occupy muddy hollows in alluvial deposits where the water supply is too



1, 2, Swallows. 3, Swift (see p. 165) 4, Martin.

small to form a lake but yet sufficient to keep the ground in a water-logged condition. Swamps are often to be met with on the alluvial deposits of river valleys. In these situations they owe their development to alternations of flood and low-water conditions. The soils of these marshes are peaty alluvial clays, which support only the coarsest grasses, reeds, sedges, and rushes. This vegetation, like that of all other swamps, is of no economic value, except that, where the firmness of the ground permits, it may be cut and saved for litter and for the production of farmyard manure. The chief agricultural interest in swamps lies in the possibility of their drainage and conversion into arable land (see art. BOGS, RECLAMATION OF). The fen lands of England, once desolate morasses, were reclaimed by an extensive and elaborate system of drainage, and the mixing together of the different strata, consisting of peat and clay or gravel, which formed their soils and subsoils. [T. H.]

Swan.—Three species of swan are found in Great Britain, of which the Common, or Mute Swan (*Cygnus olor*), is now widely distributed as a domesticated or half-domesticated bird. Its present wide range is, however, due to the agency of man, and it is more than doubtful if it is a truly indigenous species in this country. The story goes that domestic swans were first introduced into England by King Richard I, who brought them home with him from Cyprus. But on the other hand, Mute Swans are frequently shot in winter; and although these specimens are usually supposed to be escaped birds, it is not impossible that they are stragglers from the Continent, where they are known to breed in a thoroughly wild state. The largest swannery in this country belongs to Lord

Ilchester, and is situated at his seat at Abbotsbury, near Weymouth. At one time this flock included as many as 1400 birds, but latterly the numbers have become reduced, and there are now no more than 800 head. The Mute Swan is fairly omnivorous in its diet. It feeds upon aquatic plants, insects, and molluscs, and is also said to devour frogs and small fishes, though this latter point has not been properly established. Swans begin to breed in their third year, and usually lay a clutch of about five eggs; at times, however, this number is greatly exceeded, and nests have occasionally been found containing twelve eggs. Some swans have white cygnets, and such birds have frequently been supposed to constitute a distinct species, which has been called the 'Polish Swan'. But the characters which were alleged to distinguish adult Polish Swans from ordinary Mute Swans have been found to be inconstant, and the whiteness of the young is now attributed to albinism — a phenomenon which occurs sporadically in very many animals. Besides the Mute Swan, there are two other species found in the British Isles, the Whooper and Bewick's Swan, both of which are readily distinguished from the domesticated bird by the absence of a knob at the base of the bill. The Whooper Swan (*Cygnus musicus*), which is about the same size as the Mute Swan, breeds in the high north from Iceland eastwards, and in the autumn flocks south in large numbers. These flocks arrive on the coasts of Scotland and north Ireland in November, and frequently stay until the following May. In England the species is rare, but during hard weather they are sometimes to be seen even on the south coast or on large sheets of inland water. On migration the Whoopers are very gregarious, and no traveller who has wintered in the Arctic regions can ever forget the cheering 'hoop-hooper-hoop' of the swans as the wedge-shaped flocks appear in the southern sky, for their musical note is the harbinger of spring. Bewick's Swan (*Cygnus bewicki*) is considerably smaller than the other two species, but in habits resembles the Whooper. It is a winter visitor to this country, and is particularly plentiful in Ireland. [H. S. R. E.]

Swath.—A swath is the line of grass or grain as left cut by the scythe or horse mower. The expression is also applied to the grain cut by a reaper or binder in its passage across or round a field.

Swath Turner. See HAYMAKING MACHINERY.

Swede. See art. TURNIP.

Sweet Basil (*Ocymum basilicum*, nat. ord. Labiatæ), a tender annual, 1 ft. high, a native of India. The aromatic leaves are used for flavouring soup, and more rarely in salads. Seeds should be sown in gentle heat in March or April, the seedlings being eventually planted out 8 in. apart, with 1 ft. between the rows, in a warm border of rich light soil in May or June. The plants should be cut nearly to the ground when they flower, and the gatherings tied up in small bunches and dried for winter use. Some of the plants can be potted up in September and placed in the greenhouse if fresh leaves are required for winter use. Bush Basil (*O. minimum*) is very similar, but is smaller and rather more hardy. [W. W.]

Sweet Cicely (*Myrrhis odorata*, nat. ord. Umbelliferæ), also known as Sweet Chervil, a hardy perennial, a native of South Europe, which is found growing in the neighbourhood of houses in this country. The leaves, which have a flavour of aniseed, are used in salads; but it is not much cultivated in Britain, being, however, more popular in Germany. It will grow anywhere, and is increased by seeds or division. In Scotland this plant is popularly known as Myrrh, and its odour is considered attractive to bees, the insides of hives being rubbed with it in the belief that they will be induced to enter. [W. W.]

Sweet or Knotted Marjoram (*Origanum Majorana*, nat. ord. Labiatæ), a tender Egyptian biennial, which will not stand our winters outdoors, and rarely ripens seeds in this country. The aromatic leaves are used both green and dried for flavouring purposes. The shoots are cut when coming into flower in June or July, and dried in the shade for winter use. Seeds may be sown in gentle heat in March, or in drills 9 in. apart on a warm border in April, being thinned out to 6 in. apart in the rows. Common Marjoram (*O. vulgare*), a native plant; Pot Marjoram (*O. Onites*); and Winter Sweet Marjoram (*O. heracleoticum*) are also cultivated. [W. W.]

Sweet Pea (*Lathyrus odoratus*, nat. ord. Leguminosæ); introduced from Sicily about 1700. This has long been one of the most popular hardy annuals, but it is only within the last forty years that notably improved varieties have been raised; while the extraordinary present-day popularity of the Sweet Pea commenced with the still more recent improvements effected by Mr H. Eckford, who was remarkably successful in raising seedlings of new colours, which were also greatly improved in the size and substance of their flowers. Sweet Peas are so beautiful, so easy to grow, and so floriferous, that enthusiasts for them abound everywhere, and are to be found among every class of gardeners. They are grown in enormous quantities by trade growers, both for the production of cut flowers and seeds (although a great part of the seed crop is raised in California), and a number of new varieties are brought out every year. The holding of the Sweet Pea Bi-centenary celebration in 1900 led to the formation of a National Sweet Pea Society, which is a prosperous body, and among various other activities holds numerous shows. Sweet Peas may be grown in any garden soil, but a deep and rather heavy loam, deeply dug and manured in the autumn, gives the best results. Early sowing is advantageous. For ordinary purposes outdoor sowing in March will suffice, with a further sowing at the end of April to provide a succession of flowers. But in addition to making early sowings in the open, many growers utilize small pots in January or earlier under glass, planting out the seedlings in April. The Sweet Pea is quite hardy, and outdoor sowing in autumn is becoming extensively practised, and in most seasons is quite

successful. The after-culture consists of keeping off slugs, mice, sparrows, and other foes, staking, affording a mulch, or frequent surface cultivation, and feeding and watering copiously in dry weather. More room should be allowed between the plants in rows or clumps than is often the case; 6 in. apart is a good distance, and growers of blooms for exhibition allow 1 ft. or even 18 in. Better results follow the growing of the colours separately than in a mixture. Above all things it is important to regularly pick off the flowers before they form pods; where this is done the plants will continue to flower finely for as many weeks as otherwise they would days. They may be made to flower for an even longer period by cutting back the plants to a height of 3 ft. when they commence to deteriorate. It does not follow that expensive novelties are the best sorts. The following selection was lately advocated by the National Society: *White*—Dorothy Eckford, Etta Dyke, and Nora Unwin; *Crimson*—King Edward and Queen Alexandra; *Rose*—John Ingman; *Yellow and Buff*—James Grieve and Clara Curtis; *Blue*—Lord Nelson and A. J. Cook; *Cerise*—Chrissie Unwin; *Pink*—Countess Spencer and Constance Oliver; *Orange*—Helen Lewis and St. George; *Lavender*—Lady G. Hamilton and Frank Dolby; *Maroon*—Black Knight; *Striped and Flaked*—Jessie Cuthbertson, Paradise, Red Flake, and Prince Olaf; *Marbled* — Helen Pierce. A dwarf type, the Cupid, has some popularity for growing in pots and window boxes, and winter-blooming varieties for glasshouses are now attracting some attention. [W. W.]

Sweet Potato. See art. BATATA.

Sweet Vernal Grass. See ANTHOXANTHUM.

Sweet William (*Dianthus barbatus*, nat. ord. Caryophylleæ), a member of the Pinks and Carnations family, first introduced into England in 1573. The stems are from 12 in. to 20 in. high; the flowers, in large dense corymbs with bearded petals, appear from early summer till autumn. It is a perennial, but is usually treated as a biennial. Seeds are sown as soon as ripe. If the seedlings are pricked out as soon as possible, and planted out in the autumn, they will flower the following summer. The favourite distinct garden varieties include Auricula-eyed, Dark Crimson, Doubles, and White. [W. W.]

Swelled Legs.—This malady of horses is described in the art. LEGS, SWELLED.

Swift (*Cypselus apus*).—Not unlike the Swallow and House Martin (see SWALLOW and MARTINS), in the company of which this well-known migrant is often seen, it is in reality more closely related to birds of the Woodpecker kind. Except for the grey chin and throat the plumage is entirely black, and the wings are exceedingly long. The Swift arrives in May and departs for Africa in August, its stay with us being therefore shorter than that of Swallows and Martins. Like these it feeds entirely on insects taken on the wing, and is therefore entirely beneficial. The flat nest is usually made in a hole in some building, of grass or straw cemented together with the sticky saliva, and is lined with feathers. The two to four eggs are pure-white in colour. [J. R. A. D.]

Swine Erysipelas, an infectious disease due to a specific organism (*Bacillus rhusiopathiæ suis*). The principal mode of entrance into the body is believed to be by the digestive canal, but access is possible by means of small skin abrasions or minute wounds. One attack generally confers immunity. It is practically unknown in this country, but outbreaks occur in America and many countries of Europe. It is somewhat difficult to distinguish from swine fever. The symptoms supervening on a period of about three days' incubation are as follows: refusal of food, sometimes vomition or retching without actual emesis, a high temperature (frequently 104° F.), torpidity and indifference to surroundings, hiding away in the bedding, great weakness and paralysis, muscular spasms and grinding the teeth, constipation, swollen eyelids. Spots appear two or three days later upon the belly and hairless parts of the thighs, and upon the throat and ears; they change from a bright red at first to purple, and unite in irregular patches. Diarrhœa and a fall of temperature precede a fatal termination, which may occur in from one day to a week. See SWINE FEVER. [H. L.]

Swine Fever.—Three separate but similar pathological conditions embracing as many different diseases have been called swine fever. They may with more exactness be described under the headings of swine plague, infectious pneumonia, and hog cholera. The first is characterized by a septic gastro-enteritis, and is associated with inflammation of the heart, the liver, and voluntary muscles, and with hæmorrhagic nephritis caused by a small immobile bacillus. The second or pneumonic form of disease affects the pleuræ as well as lung substance, with a disposition to gangrene, and the production of cheese-like material, resulting from the action of an ovoid bacterium. Hog cholera, first so called in America, is also regarded as diphtheria or pneumo-enteritis, and affects chiefly the mesenteric glands and the large intestines. Ulceration of the intestinal glands immediately behind the ileo-cæcal valve is a prominent lesion. This malady develops more slowly than the two above named, and secondary infection of the pulmonary organs is common. This form of infectious disease is the one most generally met with in Great Britain, and pathologists distinguish it by the differences in the specific microbes, which are ovoid, motile, and aerobic (and facultatively anaerobic).

The above outlines of swine-fever pathology will enable the purely practical pig-keeper to appreciate the tardy efforts of the Board of Agriculture, and to understand why there is so much delay in arriving at a verdict and carrying out the present somewhat unsatisfactory regulations. The veterinary inspector merely carries out the duty of sending the essential organs, in a proper way, to the Board of Agriculture, and cultures are made to establish the presence or otherwise of the specific bacillus. This is the factor which causes nearly all the exasperating delay of which pig-keepers com-

plain so bitterly. Swine fever is an infectious and contagious disease caused by a specific organism, and the period of incubation is said to be about five days, because that is the time occupied by inoculated subjects. Possibly it may be a little longer when the malady is communicated by contact. The temperature varies from 104° to 106° F.; the animal appears ill, and in most cases, but not always, a rash comes out on the skin. More important than anything else to the swine-keeper is an early diagnosis, to enable him to instantly isolate an animal with the slightest suspicion, and for this reason his attention is invited to the following symptoms: dullness, loss of appetite, retiring from its fellows, seeking a dark corner, or burying itself under litter, an expression of dejection, hanging ears, half-closed and watery eyes, reddened and spotted conjunctival membranes, with a morbid secretion around the eyelids; the latter being often preceded by red spots on the ears, or a blushing redness about these organs. There is much heat and sensitiveness to the touch in the red spots at first, but they later on become cold and devoid of sensation, the animal making no sign of feeling if pricked with a pin. Grinding of the teeth, or a grating sound produced by transverse movements of the jaw; trembling, convulsions, and contraction of the flexor muscles of the limbs mark the progress of the disease. (It is the latter that causes the animal to stand on his toes.) Paralysis, either of the hind limbs or of the body generally, is succeeded by loss of control over the sphincters, and the involuntary passage of fæces and urine. As with most acute febrile diseases, there is at first constipation. This gives way to diarrhœa, convulsions, perhaps cough, and finally a collapsed or comatose condition before the animal dies. An outbreak of swine fever must be immediately notified to the local authorities. No cure for this very fatal malady is known. [H. L.]

Sycamore, Scots Plane, or **Great Maple** (*Acer Pseudoplatanus*) belongs to the Maple genus of the family Aceraceæ, characterized by having opposite, stalked, simple leaves without stipules, palmately veined and often palmately lobed; small regular flowers, often greenish and generally hypogynous, with 4 to 5 sepals and separate petals, and 4 to 12 (usually 8) stamens; and a dry 2-winged (occasionally 3- to 5-winged) samara fruit breaking into two (or three to five) separate 1-winged portions, whose single closed chamber generally contains one seed. The only other species of the Acer genus commonly found in British woodlands are the indigenous shrublike Field Maple, common in hedgerows and underwoods, and the Maple, or Norway Maple (see MAPLE), introduced, like the Sycamore, from Continental Europe, and long naturalized in our woods. Sycamore can easily be distinguished from Maple in winter by its yellowish buds (and not red-brown), in spring by its flowers only appearing after the foliage is flushed (and not along with or just before the foliage), and from spring to autumn by its having 5-lobed (not 5 to 7) bluntly toothed leaves, only pointed at the tip of each lobe (and less resembling those of the Plane tree). Its hard and whitish wood (sp. gr. 0·93 green, 0·66 seasoned) is only durable when used in dry places, but is prized for making calico-rollers when measuring from 9 to 11 in. and upwards in diameter. In the vicinity of mills it is thus one of the most profitable trees, and especially when only available in small quantities. It forms a deep root-system, and therefore thrives best on a deep soil, or where the subsoil is fissured and easily penetrable. Sandy loams suit it well, but its finest growth is attained on land containing a fair amount of lime. It is more suitable than Maple for planting on hilly land, but apt to be nipped by frost in damp hollows. Its growth is best when mixed with other broad-leaved trees (especially Beech), and it reaches maturity at about 70 years of age. It bears seed freely from about 30 to 35 years of age onwards, and often (along with Ash) seeds itself thickly in thin woods, though usually only to be eaten by rabbits. One pound contains about 6000 seeds, and yields about 3200 seedlings, which germinate in four to six weeks' time. The seed may either be sown in autumn, or kept in dry sand and sown in spring closely in drills with a covering of about ½ in. of earth; but in either case many of the seeds may fail to germinate, or else only come up in the second year. Seedlings grow quickly and can be set in the nursery lines when 1 or 2 years old, and put out as 1-year-2, or 2-year-2 transplants. They speedily establish themselves, and grow rapidly at first. Like Ash, seedlings in natural woods can endure heavy shade, but during and after the pole-stage of growth Sycamore needs room for lateral expansion; for it belongs to the light-demanding trees. In coppices it throws out long, straight stool-shoots, but its reproductive power soon weakens, and especially if the cut be not made close to the ground. It is not, however, of much use in underwoods, as it has little value until of fairly good size. But the good price obtained for well-grown stems, and the ease with which it effects natural regeneration wherever the soil is not thickly overgrown with weeds, indicate that in the future it may be found profitable to encourage the growth of Sycamore to a far greater extent than has hitherto been the case in British woodlands. It stands the sea-breeze well, and resists wind, so that it is often planted in wind-screens and shelter-belts, especially near the sea-coast. [J. N.]

Sycamore.—Parasitic Fungi.—The well-known black blotch on leaves of Sycamore, Maple, and other species of *Acer* is caused by *Rhytisma acerinum*, an Ascomycete fungus. The blotches contain masses of fungus filaments, and are yellow at first but soon turn black. The disease is spread chiefly by ascospores, which develop in the rotting fallen leaves, and are dispersed about the time new leaves unfold next summer. Another form of leaf-spot with yellow blotches dotted with black points is due to *Rhytisma punctatum*, but it is less common. Several other leaf-spot fungi have been recorded, none of them destructive. Considerable damage may be done to young trees when the foliage becomes coated with

white powdery mildew (*Uncinula*), one of the Erysipheæ (see FUNGI—'Ascomycetes').

Treatment.—All these fungi may be checked by regularly collecting and burning the fallen leaves.

The art. BEECH—PARASITIC FUNGI should be consulted for wood rot, stem canker, and seedling disease. [W. G. S.]

Syenite, a completely crystalline igneous rock fairly rich in alkalis, but with less silica than granite, and less lime than diorite. It contains some 5 to 6 per cent of potash and 2 to 4 per cent of soda. Syenite thus typically consists of a potash-felspar, with hornblende, dark mica, or augite; silica is not present in sufficient quantity to produce any appreciable amount of quartz. Syenite is comparatively rare, since it requires a certain balance among the chemical constituents. It occurs in Britain at Mount Sorrel in Leicestershire, but in few other places. Its *soils* resemble those of granite, but contain less coarse sand. [G. A. J. C.]

Sylvicultural Characteristics of Trees. See TREES, SYLVICULTURAL CHARACTERISTICS OF.

Sylviculture is that main branch of forestry which deals with the formation, tending, and renewal of woodland crops (see also arts. on FORESTRY and on WOODLANDS—MANAGEMENT, PROTECTION, AND UTILIZATION). The main scientific foundations of the modern art of sylviculture, as distinguished from the old national form of arboriculture in Britain enforced from the time of the Statute of Woods (1543) down to about the end of the 18th century, are chemistry, soil science, plant physiology, and climatology; and its main aim is to grow crops of timber in the manner most profitable to the landowner. With regard to sylviculture, one has first of all to consider the special peculiarities and general characteristics of the different kinds of trees, and the different methods of treatment that can be given to them as woodland crops, before dealing with the three chief stages in the growth and development from seedling to mature timber: the formation of woodlands, or sowing and planting; tending, or weeding and thinning; and renewal by reproduction through stool-shoots and root-suckers, or regeneration by means of seed shed naturally or sown artificially.

1. OUR WOODLAND TREES.—The timber crop which can be grown in the British Isles comprises, owing to our mild, equable, damp climate, a very large number of different kinds of trees for so comparatively small an area. The indigenous trees which can be profitably grown as timber crops are very limited in number, and include Beech, Hornbeam, Alder, Ash, Oak, Scots Elm, Aspen, Birch, White Willow, and among conifers only the Scots Pine, not reckoning the minor indigenous trees and shrubs found casually in highwoods or grown in coppices and underwoods, such as Cherry, Rowan, Sallow, Field Maple, Hazel, &c. Many valuable trees now thoroughly naturalized were introduced by the Romans, including English Elm, Chestnut, Lime, Black Poplar, White Poplar, and Horse-chestnut; while subsequent introductions have been, in the 15th century, Crack Willow, Sycamore, and Spruce; in 16th century, the Maritime Pine; in 17th century, Silver Fir, Norway Maple, and Robinia; in 18th century, Larch, Weymouth and Corsican Pines, and American Black Poplar; in 19th century, Austrian Pine, Nordmann's and Great Silver Firs, Douglas Fir, Menzies Spruce, Lawson's and Large-coned Cypresses, *Thuja gigantea*, and Japanese Larch; and in the 20th century, the American Larch. Though the countries to which these trees are indigenous exhibit marked differences in climate, yet they can all thrive here as woodland crops worked purely on commercial principles for the growing of marketable timber. For poor land the conifers are on the whole the most valuable, not only because they are in general much less exacting as regards the quality of the soil, and have usually a greater power of accommodating themselves to land which does not quite supply their normal requirements, but also because they usually grow up into good marketable dimensions long before some of the broad-leaved trees, and especially some of the hardwoods (*e.g.* Oak), can be profitably marketed. And this has the double advantage of locking up less capital (land plus growing timber crops) and giving earlier returns from what is even under the most favourable circumstances an investment giving only tardy returns.

2. THE DIFFERENT FORMS OF WOODLAND CROPS.—In the Statutes relating to land valuation, rating, and succession duty, and also in all the official returns published by the Board of Agriculture, the woodlands throughout Britain are classified either as 'Coppices' or 'Woods and Plantations'. This is merely a continuation of ancient law and custom, for both under the old English forest law and under the common law applying to woodlands not included within any forest boundary, the woodlands were either coppices (*sylvæ cædvæ*), whether simple or stored with standard trees, or woods (*saltus*), and important legal differences have always existed, and still exist, in England between these two classes of woodland crops on entailed estates. But from a sylvicultural point of view, woodlands may be treated according to one or other of the following different methods:—

I. *Coppices or Copses.*—(1) Simple; (2) stored with standard trees, preferably raised from seed.

II. *Highwoods*, to be renewed by (1) clear-felling, with artificial regulation by sowing or planting; (2) successive falls or partial clearances, which may be either (*a*) occasional or more or less regular falls throughout the whole wood, with natural or artificial regulation; or (*b*) natural regeneration in groups, by felling in patches; or (*c*) uniform natural regeneration, by means of regular partial clearances made to stimulate seed production, utilize good seed years, and gradually remove the mature parent trees when the young crop has established itself and needs more light.

3. THE FORMATION OF WOODLANDS on waste lands or poor tracts thrown out of arable cultivation must take place artificially by sowing or planting, unless, as is rarely the case, the area

can be stocked from light seed shed by a neighbouring wood, and even then many blanks would have to be filled by planting. In our damp climate, favourable to the growth of rank weeds, sowing is impracticable and planting almost universal. To provide the plants needed, seed has to be obtained of the best quality procurable, and the young plants are raised in nurseries by being sown broadcast, or in drills on seedbeds, then lined out into transplant beds, usually as 2-year seedlings, where they generally stand for other two years, and are put out as 2-year-2 transplants (see NURSERY). To get seed of the best quality, from well-grown middle-age trees, is just as important for successful timber-growing, as getting first-class sires and dams is to the stock-breeder; only the best is the most profitable in the end. But trees have this advantage over animals, that diseases are not inherited, though a weakly constitution predisposing towards easy attack by fungous diseases may quite possibly be inherited, and may become more marked on any soil or situation not quite suitable for the given tree crop. The various methods of planting in use are: (1) notching or slit-planting with naked seedlings or transplants, a method only suitable for light, friable, sandy soil, and even then preferable in the form of perpendicular notching with a flat-faced dibble or narrow ditching spade; (2) pit-planting with transplants, either with naked roots or with balls of earth attached to them; and (3) mound-planting on wet land (see PLANTING). Wet land should be thoroughly drained before planting, and soil preparation carried out by cutting and burning weeds and rubbish. On old arable land the planting of Scots Pine is apt to induce root disease, and on poor soil an admixture of White Alder is often beneficial through the supplies of nitrogen obtained in its root nodules, and through its power of throwing up root-suckers plentifully. Quick-growing hardy kinds of trees, like Larch, Pine, and Birch, are sometimes planted as 'nurses' to protect less hardy kinds, like Silver Fir, from frost at first; but in such cases the nurses should be cut out as soon as they have served their purpose, otherwise they suppress the main crop, and grow up into a thin and unsatisfactory wood.

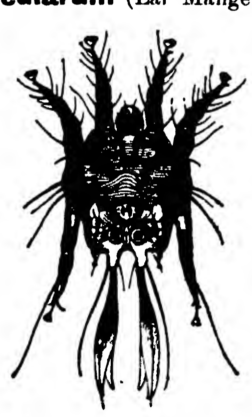
4. THE TENDING OF WOODLANDS consists in (1) the weeding and cleaning of young plantations and thickets of natural regeneration; (2) the thinning of pole woods and middle-aged crops; and (3) the partial clearance of maturing woods, in order to stimulate increment on the stems. The object of weeding and cleaning is to enable the young plantations and thickets to establish themselves in the form desired. Thus, besides freeing the tops of the plants from strong growth of grasses and other weeds threatening to overlay and suffocate them, softwoods like Aspen, Birch, or Willow, or any other kind of tree not desired in the crop, should be cut out. The thinnings, which generally begin at about 17 to 20 years of age in conifer, and later in broad-leaved crops, are made with the object of enabling the best-grown young trees to continue to develop well, so that the ultimate crop obtainable may show the largest profit on the capital invested in producing it. Under our old national system of arboriculture, young plantations and maturing woods were habitually overthinned, and the trees therefore grew up much rougher and more branching than is now desirable; but if a rational amount of thinning is not done, the crops get too thick and the crowns of foliage too small for healthy growth. Ordinarily, the trees which should be removed are (1) those dead or dying; (2) those diseased, infested with insects, or much suppressed; (3) those interfering with the growth of trees likely to be of greater ultimate value later on; and (4) forked and badly shaped trees not likely to have much value as timber. Thinnings may be light, moderate, or heavy, though these terms are rather indefinite, as what might be a moderate thinning for light-demanding trees, like Oak, Ash, Larch, and Pine, might be a heavy thinning or an overthinning in shade-enduring crops like Silver or Douglas Fir, Spruce, or Beech. The percentage of the crop removed at each thinning may vary greatly according to the kind of tree and the age of the crop, the quality of the soil, and the elevation, aspect, and slope of the land; and it may vary from below 5 to over 10 per cent of the standing crop at different ages. Thinnings generally begin when the price obtained for the material cut out more than pays the cost of cutting and extraction; and, of course, the larger this income or partial return from the capital sunk in the plantation is, the less the net cost of the young crop just after a thinning. This tends to induce somewhat heavy thinning; but if the woods are to be managed on purely business principles it is in the end more profitable to thin moderately and at regular intervals of from 5 to 10 years, according to the given conditions, than to make heavy thinnings before the crop is nearing its maturity. Thus heavy thinnings amounting to partial clearances generally give good increment on the stems, though it increases the risk of windfall. In conifer woods intended to be worked solely for providing pitwood timber, heavy thinnings by cutting out the largest poles may, however, prove the most profitable treatment. Pruning is unnecessary in closely grown crops, and even in standards over coppice it is seldom profitable, as it tends to make the trees die off in the top.

5. THE RENEWAL OF WOODS may take place (as already indicated under 2) by methods varying according to the form of the crop. Simple coppices are cut back to the stool with a clean slanting stroke as close to the ground as possible, and reproduce themselves by throwing out stool-shoots or root-suckers. In stored coppice or coppice with standards, along with the underwood the standard trees grown for timber are also removed in a more or less fixed proportion, all the trees of the oldest class (say of four or five rotations of the coppice) being felled together with an equal number of the next-age class, and the other younger-age classes cut in larger number, the object being at each rotation to remove those that are not well grown, and only to leave those that seem likely to continue growing well

(see Coppices). The renewal of highwoods (see Highwoods) takes place in Britain by planting, when clear-felling is adopted as is very often the case; and here the planting area is cleared and burned to destroy the rubbish, and then replanted. Natural regeneration from self-sown seed is here only usual in the case of the Beech woods on the chalk hills of southern England, and of Scots Pine in the Strathspey district of Scotland; but it might be advantageously carried out to a much larger extent than at present in most of our woodlands formed with deep-rooting kinds of trees (but not in Spruce woods), as Ash, Sycamore, Larch, Oak, Silver and Douglas Firs, *Thuja gigantea*, and most kinds of forest trees come up fairly thickly wherever the soil is in good condition, and not overrun with a rank growth of weeds—provided always that rabbits are kept down. The method of occasional falls (see 2 above) is most suitable for ornamental woods and broad shelter-belts; that of regeneration in groups or patches for underwoods of broad-leaved trees and of Silver Fir; and that of uniform natural regeneration by means of successive partial clearances before, during, and after the good seed years for Beech, Scots Pine, and probably also Douglas Fir and *Thuja gigantea*. Where blank spaces remain in highwoods by any of these three different methods, they can easily be filled by planting them up with whatever kinds of trees seem best suited to the soil and situation, so as to have ultimately the largest and most valuable crop of timber that the land is capable of yielding. [J. N.]

Sylvine.—This mineral, composed of potassium chloride (KCl), popularly known as 'muriate of potash', closely resembles rock salt, but occurs far more sparingly. It cannot, indeed, be obtained separately on a commercial scale, even from the deposits of potash salts in Prussia. In that region some of the sylvine has arisen from the alteration of carnallite. A mixture of rock salt and sylvine is raised at Strassfürt under the name of *Sylvinite*. [G. A. J. C.]

Symbiotes auricularum (Ear Mange of Cat and Dog).—This species lives in the ear of the cat, dog, and ferret, and gives rise to so-called Otiocariasis of the ear. The acarus is small and white, and causes intense nervous disturbance. It breeds in colonies. The males are about 0·3 and the females 0·4 mm. in length. *Treatment* consists of pouring into the ears warm oil, carbolic, or chinosol. [F. V. T.]



Symbiotes communis equi, male, ventral surface × 60

Symbiotes communis (Colonial Leg Skin Mites).—The so-called Symbiotes are colonial scab mites. They do not excavate any sub-epidermic galleries. In form they are oval, not rounded, and the legs are longer and more easily seen than in the ordinary scab mite. They cause localized scabies, the extension of which is slow. They chiefly locate themselves on the legs, especially in the hollows of the feet. One variety (*S. ovis*) is now and then found on the feet of sheep, and according to Goodall is one of the forms of footrot. It has occurred on sheep in North Devon, Kent, and Hampshire. The mites form a mass of pinkish-grey colour between the toes, and are said to give rise to lame feet. The skin becomes reddened, moist, and a thin scab results.

Treatment has been found successful by washing the feet in a 2-per-cent solution of lysol. [F. V. T.]

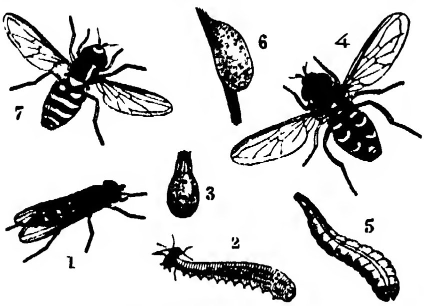
Symplectoptes cysticola (Skin Mite of Poultry), a minute acarus, ·22 mm. long, which is found on poultry and game birds. The acari live in the connective tissue of the birds but do not seem to affect the health of host, but they give rise to tubercles from the irritation they set up. [F. V. T.]

Synodendron cylindricum (Rhinoceros Beetle).—This beetle is one of the Lamellicorns. It varies in length from ½ to ⅜ in. The colour is black, body cylindrical, and the legs short; the front of the thorax is scooped out so as to leave five toothlike projections, and the head of the male has a hornlike appendage; the female has one also, but not so long; this horn gives it the popular name of Rhinoceros beetle. The larvæ resemble others of the same group; the head is small, body dirty-white, the front part thicker than the hind, which is less curled up towards the abdomen than in the chafer or the stag beetle. They live in the wood of Ash, Birch, Beech, and Willow, and sometimes do considerable damage; but they mainly attack unhealthy or decaying timber. It is common from the Midlands southwards, but is rare farther north. Decaying timber should be destroyed wherever these larvæ are found, so as to save other trees in the neighbourhood. [F. V. T.]

Syrian Goat.—This breed, known also as the Mamber Goat, presents characteristics differing in many respects from the Common Goat, and distinct also from the Nubian. The ears are longer and much wider than in the latter, often measuring 16 in. in length and 6 in. in width, with a slight curl outward at the extremity. The facial line is straight in the female, but in the male the forehead slightly projects. The horns, when these are present, incline to the rear and form a spiral similar to those in the ram but less heavy. The hair is generally black and of considerable length, measuring 10 or 12 in. It is used largely in the East in the manufacture of carpets and also for tentcloth and cordage. There are several varieties of this breed, but that which is most valued as a milker is the Samar, which yields an abundant and rich milk. From this milk the far-famed butter of Aleppo is produced, which is in great demand throughout Asia Minor. There exists a white variety of the Syrian Goat in the neighbourhood of Damascus, but its reputation as a milker is not equal to that of the Samar. [H. S. H. P.]

Syrphus, a genus of two-winged flies, whose maggots live, during the summer and autumn, upon aphides, devouring immense quantities. They belong to the family Syrphidæ or Hover Flies.

S. balteatus (fig. 1, slightly magnified) is bright ochreous; eyes chocolate colour; thorax coppery-



Syrphidæ—Hover Flies

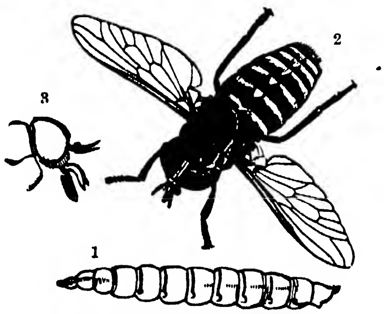
green; body with one or two broken, two narrow, and three broad orange bands; larva fleshy, tapering to the head, with orange and dark spots down the back (fig. 2 shows it sucking a plant-louse); pupa horny, pear-shaped, dusky (fig. 3).

S. ribesii, Linn. (fig. 7), is very abundant. It is ochreous; eyes and antennæ chocolate; the latter orange beneath; thorax bottle-green; scutel ochreous; body with two large spots, two broad, and one narrow orange band. Larva and pupa similar to the last. Figs. 4, 5, and 6 represent *Catabomba pyrastri*, an insect of same family (see art. CATABOMBA). [J. C.] [F. V. T.]

Syrup.—The name syrup is given indiscriminately to all viscous liquids rich in sugar. It is most commonly applied to the purer grades of treacle obtained in the refining of sugar ('golden syrup', &c.). These contain commonly about 25 to 35 per cent of water, and 65 to 70 per cent of sugars (sucrose, glucose, and fructose). One of the cheapest of syrups is that known as starch-syrup', obtained in the manufacture of glucose from starch. It contains usually about 30 to 35 per cent of glucose and 45 to 50 per cent of dextrins, and is used to adulterate the syrups obtained in the manufacture of sugar. These are the only syrups likely to be met with upon the farm, the fruit syrups being prepared only for human consumption. Syrup is occasionally used for sweetening foods and rendering them more palatable, but this object can usually be effected more economically by means of molasses. [C. C.]

T

Tabanidæ, a family of blood-sucking flies, including the 'cleggs' or 'gadflies'. The males are inoffensive, but the females pierce animals with their lancet-formed mouths, and suck their blood. One of the most familiar examples is



Tabanus bovinus (the Ox Gadfly)

Tabanus bovinus, the Ox Gadfly, which is conspicuous by its great size. The larvæ (fig. 1) live in the earth, where they change to pupæ, and the flies are abundant in June, July, and August. The fly is brown; the body is pointed, and the sides are ochreous at the base. The female is larger (fig. 2; fig. 3 shows the head in profile); the face is of a grey colour; the short antennæ are tawny at the base. The thorax is indistinctly striped with grey; the edges of all the abdominal segments are downy and whitish, with a similar line of triangular spots down the back; the two wings have bright, brown, pinion edges and nervures, and the shanks are buff-colour. Some of the smaller species are equally troublesome, *e.g.* the grey 'clegg', *Hæmatopota pluvialis*, which attacks both men and cattle in the summer. [J. C.] [C. W.]

Tabanus, a genus of blood-sucking diptera. See TABANIDÆ.

Tænia, the genus to which most of the tapeworms belong. All domesticated animals, as well as man himself, are liable to be attacked by them. The internal parasites known as bladderworms were long considered to be entirely different creatures; but it is now known that all tapeworms pass through the bladderworm stage in the course of their development, and require two different animals or 'hosts' to live in if they are to complete their life-history. Thus the bladderworm often present in the liver of the rabbit, and attaining in that animal no further development, will, if eaten by a dog, give rise to a tapeworm, *Tænia serrata*.

The bladderworm always consists of a bag or 'cyst' enclosing one or more heads (*scolices*) provided with hooks and suckers. When eaten by another animal the cyst is dissolved by the digestive juices, and the scolices attach themselves to the walls of the intestine and, by budding off segment after segment, develop into tapeworms. Each segment (*proglottis*) of the tapeworm, when mature, is full of eggs, and these are constantly passed out by the infested animal. If eaten by the second 'host' they become bladderworms. An animal suffering from tapeworm is not cured unless the head or scolex is detached and ejected, and strong purgatives (male-fern, areca nut, &c.)

are employed to effect this purpose. But much may also be done in the way of prevention, and if a dog, for instance, is not allowed to touch the viscera of hares or rabbits it will not contract the tapeworm disease due to *T. serrata*.

The disease known as 'gid' or 'staggers' in sheep is due to the presence of a large bladderworm in the brain. This bladderworm, if eaten by the sheep-dog, gives rise to the tapeworm, *T. cœnurus*. Obviously it is folly to allow a dog suffering from tapeworm (which may be of this species) to run among the sheep, and it should be rigidly kept away from them until cured. Perhaps the commonest human tapeworm is *T. solium*, of which the bladderworm is to be found in the flesh of the pig. See art. TAPEWORMS. [C. W.]

Tail Docking. See art. DOCKING.

Talc, a pale-coloured mineral of a flaky nature, so soft that it can easily be scratched by the thumbnail. It is a hydrous magnesium silicate, $H_2Mg_3(SiO_3)_4$. When massive, it is styled *soapstone* or *steatite*, and is sold as a lubricating material. Talc forms schistose rocks, but is not a very common rock-forming mineral. [G. A. J. C.]

Tall Fescue, a grass of high nutritive value. See ARRHENATHERUM and FESCUE GRASSES.

Tallow is the name given to the fat of oxen, cows, calves (beef tallow), sheep and goats (mutton tallow), when separated from the connective tissue with which it is associated in the animal. This separation is effected by boiling the rough fat and adherent tissue with water, the clear melted fat which rises to the surface being then drawn off. To extract the rest of the fat the animal tissue, &c., is treated with a little dilute sulphuric acid in order to 'cut' the cell membranes, and then again boiled up with water. This second crop of tallow is usually inferior to the first melt. For some purposes the tallow thus obtained is further refined and bleached.

The fats from different parts of the carcass vary considerably in value, and for the best varieties of tallow, such as are used for the manufacture of margarine, the more valuable kidney fat ('suet') and bowel fat ('midgerum fat') are rendered separately and not mixed with the caul fat. The quality—especially the hardness—of tallow varies with breed, age, and feeding of the animals. Foods rich in carbohydrates and poor in oil (*e.g.* grass, hay, straw) tend to give a hard tallow. Male animals usually yield a harder tallow than females. Mutton tallow is very similar in composition to beef tallow, but is usually harder than the latter. It is also more liable to turn rancid, and hence cannot be used in the manufacture of the finest margarine or high-class toilet soaps.

The common classes of tallow are often subjected to hydraulic pressure, whereby the liquid ingredients are largely expressed and form a liquid or semi-solid product known as 'tallow oil'. This is chiefly used in admixture with mineral oils as a lubricant. The solid residue in the press ('stearine') is used for candle-making, for which purpose also much unpressed tallow is used. 'Stearine' obtained in similar fashion from high-class tallows is used for edible purposes as an ingredient of compound lards and suet substitutes.

For the use of tallow in the manufacture of margarine, see art. MARGARINE.

The tallow industry has now reached very considerable dimensions, the home production of the United Kingdom alone being estimated at well over 100,000 tons, representing a value of £3,000,000. The products are chiefly absorbed by the soap-making, candle-making, and margarine industries. [C. C.]

Talus.—This term, meaning a projection at the foot of an upright object, is applied in geology to the slopes of detritus that gather under mountain walls. Coarse taluses, such as are mainly formed by frost action, are styled *screes* in the north of England. Any material worn from the higher summits may go to increase the talus. Taluses typically assume conical forms, and unite by overlapping at their feet. As the finer material sinks to the base through the interstices between the coarser stones, taluses remain rugged on the surface, with holes that are dangerous for sheep or cattle wandering on the slopes. Some taluses serve for the growth of trees, but through slips in the talus, or the descent of new material from above, such trees are liable to abrupt destruction. A few hours of storm will sometimes visibly extend a talus in a mountain district, at the expense of grassy pasture-land. The decay of the talus-blocks, and the washing out of the fine material, furnish, however, the excellent alluvium which supports life in otherwise barren uplands. [G. A. J. C.]

Tamarind (*Tamarindus indica*, Linn., nat. ord. Leguminosæ), a large evergreen tree cultivated throughout India and most tropical countries, luxuriating on a deep alluvial soil. It flowers in April and May, and affords its ripe crop in the ensuing cold season. The young shoots or seedlings have been a valued antiscorbutic since the most ancient times. The pulp of the ripe pod is a favourite ingredient in curries, chutneys, &c., and valued in pickling fish; it is also largely utilized in the preparation of a syrup employed in sweetmeats. The tamarind of European commerce is prepared by carefully removing the shell, seed, and other impurities, then packing the reddish-brown pulp, layer upon layer, with salt or sugar between, and closing in the package with a coating of boiling syrup. The supply of the United Kingdom comes mainly from the West Indies. [G. W.]

Tamarisk, a genus (Tamarix, nat. ord. Tamariscineæ) comprising about twenty species of ornamental greenhouse and hardy half-evergreen shrubs and small trees, with feathery foliage, and white or pink flowers. They thrive in sandy soil, and are particularly well adapted for planting by the coast. *T. anglica* is a native plant; *T. gallica*, which is a favourite for planting, attains 5 to 10 ft. in height, and flowers from July to September; *T. Pallasii*, a native of Eastern Europe and Afghanistan, is a particularly handsome kind, and the var. *rosea* is an improvement on the type. Other hardy kinds are *chinensis*, *hispida*, and *tetrandra*. Propaga-

tion by cuttings. The manna of Mount Sinai is produced by a variety of *T. gallica*. [W. W.]

Tamworth Pigs have undergone a considerable change in form, colour, and early-maturing qualities during the last few decades. In its unimproved form the Tamworth was mainly kept in the counties of Stafford and Warwick, and was of medium size, dark grizzly in colour with black skin spots, long in snout, short in ear, heavy in shoulder, short in the back, and light in the hind quarters. It was fairly prolific, the young were hardy and somewhat wild, whilst neither young nor old were noted for their good temper. The fat pigs were slow in maturing, but the pork possessed a large share of lean. Some years ago this breed was taken up by an enthusiast, who endeavoured to improve their defects, for he recognized that the majority of the pigs of that period were unsuited for the manufacture of bacon and hams of the finer qualities. Subsequently Large and Middle White pigs of both sexes were used for crossing, when some very fine cross-breds resulted. At the present time the fashionable colour of the Tamworth pigs is a golden-coloured red. The nose is shorter, the ear longer, and pendent instead of being pricked, the jowl is heavier, the shoulder is lighter, the back longer, and the hind quarters and hams are better developed than in the oldfashioned type of Tamworth. A considerable number of Tamworth boars have been exported, but except in Canada they have not given complete satisfaction when mated with the Berkshires and others of the more compact breeds for the production of bacon pigs. Present-day breeders of Tamworths find great difficulty in procuring a change of blood owing to there being so few tribes or families whose pedigrees have been recorded in the herd book. This may be due to two causes: the small quantity of foundation stock, or the limited number of breeders who have recorded their stock, or who, having been successful in the show yards, have gained a notoriety for the superiority of their pigs for exhibition purposes. [S. S.]

Tanface Sheep, a name sometimes applied to the Welsh Mountain Sheep (see this article).

Tank (Liquid-manure).—The liquid-manure tank, when placed beside the dungstead, serves as a receiver of the drainings from the heap, and the sewage from the special drains that lead from the various houses in which the animals are accommodated. The tank will also be convenient should it ever become advisable to sprinkle the dungheap with the liquid manure. If the tank be made long and narrow it will be all the easier to cover in. Either at a side or an end of the dungstead will usually be found a stretch of wall alongside which the tank may be constructed. A tank 20 ft. long, 3 ft. deep, and 2½ ft. wide will hold close on 950 gal. of liquid. Such a tank with a concrete bottom, sides either of brick and cement or concrete, and a cover either of flat stones, or concrete again, is cheap and serviceable. It may not be always practicable to get the inner side of the tank put close up to the outer face of the dungstead wall. Where this can be easily done, however, the two need be no farther apart than the breadth of a narrow ledge (6 to 9 in.) for support of the covers on that side. In fact, where concrete happened to be adopted as covering medium, the two could be flush if the ends of angle-iron supports were let into the wall. It is easier to make the tank when the dungstead is being constructed, because the wall against which the tank is to be formed can then be founded deep enough to act as the back side of the tank. No drains dealing with water from the roofs should be in connection with the liquid-manure tank, either directly or by way of the dungstead itself; only those from the live-stock houses should be connected to it. A pump is a necessary addition to the tank (see PUMPS). [R. H.]

Tanning. See arts. LEATHER INDUSTRY and BARKING.

Tansy (*Tanacetum vulgare*, nat. ord. Compositæ), a strong-growing aromatic herb, 3 to 4 ft. high, with finely divided leaves and bright-yellow button-like flowers, borne on terminal corymbs. The plant is easily cultivated, and may be increased by seeds or by division of the rootstock. Tansy is of some medicinal value, and is used for flavouring and colouring puddings. A crisp or deeply-cut-leaved variety is occasionally used for garnishing. [A. H.]

Tapeworms (Cestoda), a class of Flat Worms (Plathelminthes), including an enormous number of internal parasites which occur as adults in all kinds of vertebrates. All tapeworms (except Archigetes) require two hosts. The host of the adult tapeworm is a vertebrate; the host of the immature stage—usually known as a bladderworm or cyst—may be a vertebrate or an invertebrate. The bladderworm becomes a tapeworm when an appropriate second host eats the first host.

A typical tapeworm consists of (*a*) a small 'head' or scolex, with suckers and often with hooks, effecting attachment to the gut of the host; (*b*) a narrow 'neck' or growing area, from which joints are marked off posteriorly; and (*c*) a chain of numerous joints or proglottides. The youngest joints show no reproductive organs, those farther back show the reproductive organs in full activity, those farthest back show little more than a branched uterus crowded with embryos. Tapeworms are all hermaphrodite and very prolific; in many cases the ova are fertilized by spermatozoa from the same tapeworm. A ripe joint—separated from the chain by itself or along with others—is passed from the host; it breaks up and liberates the embryos on the soil or in water; some of these may be eaten by an appropriate host, within which they develop into bladderworms. Each bladderworm (proscolex, cyst, or hydatid) forms a 'head', which appears as a bud on the wall of the bladder, at first invaginated and eventually evaginated. Sometimes several millions of embryo emerge from one tapeworm.

Some of the practically important tapeworms are the following: *Tænia solium*, tapeworm in man, bladderworm in muscles of pig; *T. saginata*, tapeworm in man, bladderworm in muscles

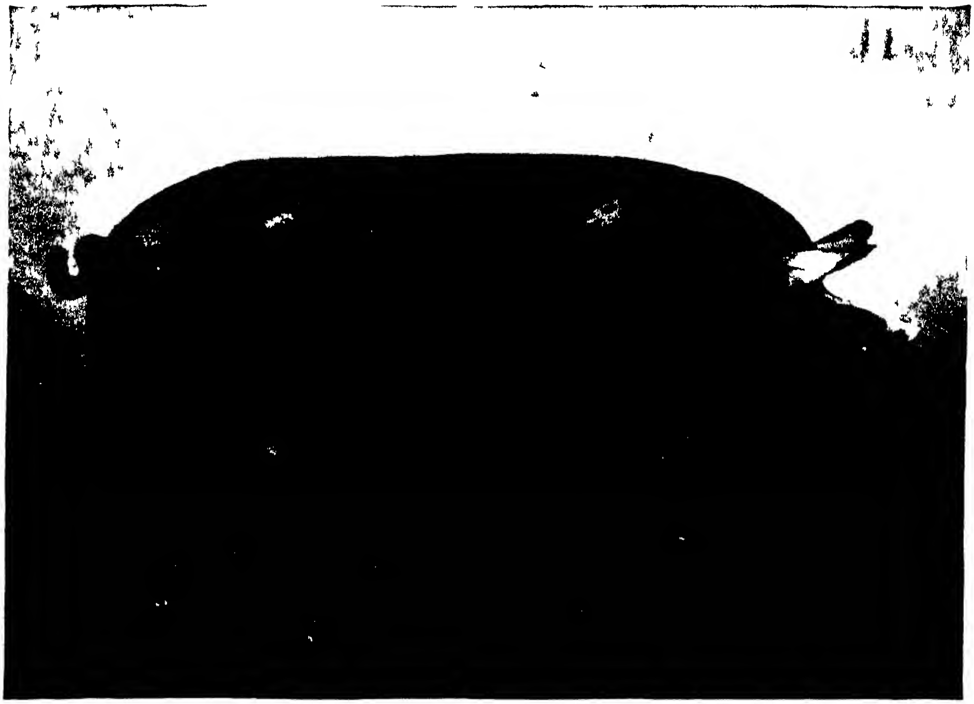


Photo Chas Reid

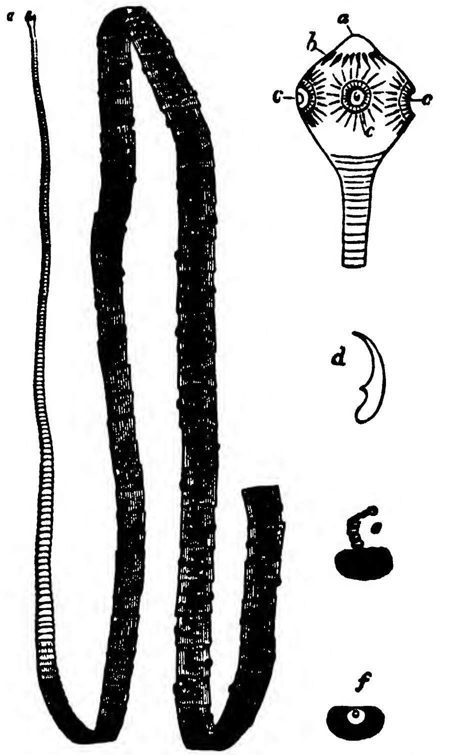
TAMWORTH BOAR—"ASHLEY ABBOT"
FIRST AT R A S E SHOW 1910

(19)

Photo Chas Reid

TAMWORTH SOW—"CONSTANCE"
FIRST AND CHAMPION, R A S E. SHOWS, 1909 AND 1910

of cattle; *T. cœnurus*, tapeworm in dog, bladderworm (sturdy) in brain of sheep, and also in ox, horse, &c.; *T. echinococcus*, tapeworm in dog and wolf, bladderworm in man, ruminants, &c.; *T. serrata*, tapeworm in dog, bladderworm in the rabbit, hare, and mouse; *T. marginata*, tapeworm in dog, bladderworm in ruminants, &c.; *T. crassicollis*, tapeworm in the cat, bladderworm in the mouse; *Bothriocephalus latus*, tapeworm in man, larva (solid, without a bladder)



Pork Tapeworm (*Tænia solium*), showing head (*a*) and long flattened body, made of segments (proglottides)

Head of *Tænia solium* (magnified). *a*, Rostellum. *b*, circle of hooklets. *c*, suckers. *d*, hooklet greatly magnified. *e*, *Cysticercus cellulosæ* with head protruded. *f*, *Cysticercus cellulosæ* with invaginated head.

in pike, turbot, trout, &c. In many cases the host of the larva or cyst is still unknown, as in three tapeworms of sheep and three tapeworms of the grouse.

Adult tapeworms are usually in the intestine of their host, but they sometimes occur in annexed organs such as liver and pancreas. They have considerable powers of movement, and may cause perforation of the wall of the intestine. It is said that many have a very limited length of life—about a year—the attaching 'head' often undergoing wear and tear. See Bladderworms, Cestodes, Measles.

[J. A. T.]

Tapioca. See art. Cassava.

Tar.—When wood is heated in a closed vessel—that is, in the absence of air needful for its combustion—the substances present in it undergo far-reaching chemical changes, and an extensive series of decomposition products is formed. A number of these are found in the semi-liquid mass known as tar; and similar, though by no means identical, products are found in the tar formed when coal is heated in the manufacture of coal gas. The very valuable antiseptic properties of wood tar are chiefly due to the phenols it contains. The best-known phenol is the substance commonly called carbolic acid, and the allied substances, cresols, guaiacol, &c., which accompany it in tar have similar properties. The value of tar, however, is due in large measure to its physical characters as a viscid liquid not readily miscible with water.

Tar has been largely used for the autumn smearing of mountain sheep to protect them from the cold and damp of winter. For this purpose it is mixed with grease and applied to the skin between the parted wool. Whilst it forms an excellent protection from severe weather, and is also valuable as a destroyer of vermin, it has the disadvantage that it discolours the wool and thus reduces its value (see Sheep, Smearing of). Shepherds find tar an excellent application for footrot and similar troubles with sheep. It serves at once to hinder the growth of the infecting organisms, and by excluding air and damp to give an opportunity for natural recuperative processes. A solution of bluestone is often mixed with the tar, but is better applied previously.

Tar is found very useful by fruit growers. Thus, to prevent the females of the Winter Moth from climbing up the trees a strip of brown paper some 6 in. wide, and long enough to go completely round the trunk, is first tied round the tree so as to leave no space between the paper and the bark, and then this strip is thoroughly covered with Stockholm tar, which forms a trap that the insects cannot escape. By the use of tar, the wounds in fruit trees that are caused in pruning thick branches can be protected, and the entrance or germination of fungus spores can be prevented (see Apple—Parasitic Fungi).

The principal use of tar, however, is for the preservation of timber. Both for wooden fencing and for the rougher kind of wooden buildings tar has great advantages, and it is specially valuable for coating wood that is exposed to constant wet, as, for example, the portion of posts that are buried in the ground. [C. M. L.]

Tawny Owl. See art. Owls.

Tea is the specially prepared leaves of the shrub *Camellia Thea*, Link, nat. ord. Ternstrœmiaceæ, a native very possibly of China, Cochin-China, and the mountains of the Assam-Burma frontier. The tea plant appears to be mentioned in the most ancient books of China; one of the references to it denotes 'tea vegetable', and the Shans and Burmans to this day pickle the tea leaf and eat it as a flavouring vegetable. It is not, in fact, till the 4th century that we obtain mention of the beverage prepared from the leaves. But by the 8th century A.D. it would appear to have become so general in China that it was then subjected to

an imperial duty. The first mention of tea by a European writer occurs in Ramusio's edition of Marco Polo's work (published in 1545). The editor therein states that he had only then (three centuries after Polo's time) come to hear of tea from a Persian merchant. Bontius (in 1631), a Dutch physician resident in Batavia, published a beautiful engraving of the tea plant and gave details of the beverage. He was the first to mention that sugar had to be used along with tea. *Moreover, he made known the fact* that black and green teas were merely due to methods of preparation and not to differences of plant employed—a fact that Europe was two centuries in accepting. In 1660 tea drinking had become so general in England that it was taxed along with coffee, chocolate, &c., and sold at the coffee houses. In 1664 the East India Company made a present of some tea to King Charles II, and by 1677 they had taken steps to secure a regular supply from China. At this time tea sold at £5 to £10 a pound, and in 1689 a direct duty was established of 5*s.* per pound on the imports. In 1722–44 the duty was fixed at 4*s.* From 1784-95 it had been gradually remitted until it fell to 12½ per cent. Unfortunately, however, in 1795 the practice of raising special money by taxing tea was again resorted to, so that in 1819 tea sustained a duty of 100 per cent, and in consequence the sales stood still at 21,000,000 lb. But by an Act of Parliament in 1833 the East India Company's monopoly was abolished; unrestricted sales thereby stimulated competition and lowered prices. At the same time the duty was once more reduced, and stood at 1*s.* 6*d.* to 3*s.* a pound according to quality. During 1909 the amount collected by the Crown on the tea which passed into home consumption was £5,907,300, or a rate of 2*s.* 7½*d.* per head of population. Running parallel with these progressions to popular favour was the effort to establish tea cultivation in India.

Lord William Bentinck in 1834 took up this matter warmly, and dispatched first one and then another expedition to China, to study the methods of cultivation and manufacture of tea, and to secure good stock. About the same time the discovery was made of the existence of indigenous tea in Assam; and this rapidly became one of the most important aspects of India's success in tea planting, since the Indian plant was found superior to the Chinese for the greater part of the Indian area. By 1840 the industry had been so thoroughly established that the Government felt the time had arrived for them to withdraw from experimental cultivation. There has in consequence been organized in India an industry the value of which may be judged of from the following circumstances: Indian tea now occupies half a million acres of land, formerly waste and unproductive; the industry gives lucrative employment to close on 550,000 persons; the capital invested comes to well over £20,000,000; the annual average exports are now over 230,000,000 lb., valued at say £6,500,000 (in 1909 the production of India was 260,000,000 lb.); as an offshoot of that great Indian industry, cultivation of tea has been organised in Ceylon and other countries; and lastly, India and Ceylon now give to the United Kingdom a regular supply of a much purer and much cheaper tea than was formerly obtainable from China.

But the Indian success may be said to have led to the reformation of the China industry, so that the methods of planting and manufacturing, perfected in India, and the machinery invented by the Indian planters, have now become *universal throughout the tea industry of the* world. The economies of large plantations, and the discovery of machinery that could do all and more than hand labour had formerly accomplished, cheapened production and thus created increased demand. The freedom from adulteration and the admitted high quality enhanced the appreciation of the Indian article, and with a reputation for superiority thus established, came the downfall of the old Chinese traffic. This may be briefly exemplified. In 1859 China supplied Britain with 76,000,000 lb. of tea, and in 1880–1 with 175,000,000 lb. In 1864 India commenced to export in sufficient quantity to justify separate recognition in official returns. In that year her exports came to 2,800,000 lb. In 1875–6 the exports of Ceylon were 784 lb., while the Indian were 24,361,599 lb. In 1900 the figures were: Ceylon, 149,265,000 lb., valued at £3,582,000; and India, 176,387,000 lb., valued at £6,118,000. By way of contrast it may now be stated that the total exports of China in 1900 were 184,533,000 lb., valued at £3,949,000; and of Japan, 61,028,000 lb., valued at £1,406,000. But the exports from India in 1906 were 236,731,623 lb.; from Ceylon, 170,527,146 lb.; and from China, 108,864,543 lb. black and green teas, and 79,506,133 lb. brick teas and dust. Lastly, the production of India during 1908 was 247,477,324 lb., and in 1909 something like 260,000,000 lb. In recent years the expansion of the production of tea in Java has been one of the most striking features of the trade. In 1908 this came to 34,165,000 lb., and in the following year to 35,721,000 lb. The proportion of that supply drawn by the United Kingdom in the former year was 19,699,000, and in the latter 23,932,000 lb. Turning now to price: during the later years of the period indicated above, the price fell for Indian teas from 13·33*d.* to 8·32*d.* per lb. in 1900; for Ceylon, from 11·63*d.* to 5·41*d.* per lb.; for China, from 7·26*d.* to 5·14*d.* per lb.; and for Japan, from 7·17*d.* to 5·53*d.* per lb. Thus while India has attained the position as leading country in supply, she has at the same time maintained a marked supremacy in price. But it must be admitted India and Ceylon owe their prosperous tea industries to the consumption in the mother country and her colonies. According to Messrs. M'Meekin & Co.'s report, Tea in 1909, the consumption to population within the United Kingdom was 6·30 lb.; and in that year India supplied 56½ per cent., Ceylon 33½ per cent, Java 7 per cent, and China only 3 per cent of the demand. By way of contrast, it may be added that the consumption in the Colonies, expressed to head of population, is even higher than in the mother country; while in Russia it was but

0·83 lb., in Germany 0·13 lb., and in France 0·06 lb.

The aim of the tea planter is a constant succession of leaf-bearing shoots. But for success, both in quality of tea and permanency of plantation, it is essential that there should be a definite season when the plants can be at rest. The young leaves of each shoot (or flush as it is called) are alone used in tea manufacture, so that this branch of agriculture manifests conditions that prevail with almost no other industry, more especially the cultivation of perennial bushes with the object of the maximum production of leaf commensurate with health of stock. Flowering and fruiting are, of course, undesirable. Success has made tea planting one of the most technical of branches in agriculture, and past failures have been largely due to the aversion to throw off ordinary experience and to embrace the departures that special knowledge had established.

Tea requires something between temperate and subtropical conditions and a well-distributed rainfall, though during the season of rest even frost is not objectionable. The entire absence of rain at any season is distinctly to be avoided. The best results are obtained under atmospheric conditions that range in point of temperature from 75° to 85° F. Higher temperatures, unless accompanied with rainfall or prepared for by protecting shade plants, are distinctly injurious. Below 70° F. slow flushing takes place, and the point may then be rapidly reached when even high prices will not compensate for low yield. As to rainfall, 60 in. have given good results, but the average amount in the better localities may be from 100 to 150 in. The chemical and physical nature of the soil is more important than the position of the land. Suitable soils on the level are preferable to similar soils on the hillsides. But the soil must be well drained and of such a nature that it can be freely permeated by the roots. Hard and water-logged soils are alike unsuited. In other words, tea requires light, sandy, deep loams. Stiff clays are to be avoided, and loose gravelly soils, in the absence of almost constant rains, will produce stunted growth. To attain a liberal supply of leaf, a copious and well-established root system is indispensable. But the production of good tea seems closely dependent on the proportion of organic matter and nitrogen in the soil. Excess of vegetable matter leads to large, coarse, and inferior grades of tea; and scarcity, to not only small outturn, but diseased crops. It would almost seem as if flavour, if at all dependent on any special chemical property of the soil, turned on the amount of phosphoric acid and potash that may be present. On the other hand, more than a very small amount of lime—in India under 0·2 per cent—is fatal.

The tea plant is universally raised from seed. The attempt to produce stock on a sufficiently large scale, by cuttings and layerings, has been abandoned as hopeless. But it cannot be accepted that all has been done that is possible in the direction of improvement. Seed gardens can hardly be said to do more than continue to produce stock of recognized merit. Seed-bearing plants are allowed to grow without being pruned. Flowering takes place in September (a second, but less valuable, in February to March), and the fruits come to maturity in about a year. But as they do not keep well, the seeds must be packed in carefully dried soil and transmitted with as little delay as possible, and sown immediately on arrival. Sowing is made in nurseries, the seed being deposited 4 to 6 in. apart and 1 in. below the surface, on specially prepared beds. The yield from 40 lb. of seed will be something like 10,000 plants, or sufficient for 2½ to 3½ ac. of land. The plants sown in November or December will be ready for transplanting into their final positions in May to June; or they may be left till a year old, namely the ensuing November to December. The earlier period is that generally preferred. While the seedlings are being sown, the land should be well under preparation. Trees must be cut down and the stems and branches removed or burned on the spot; the land must be deep-hoed, and the desired condition of drainage established. The land should be then lined and cross-lined, the points of crossing being those where the plants are to be deposited. It is as a rule the wisest course to have the plants 4½ to 5 ft. apart each way. If planted on the square, that is to say the lines at right angles, 2722 plants will go to the acre. But nowadays it is customary to go in for 'triangular' planting, that is to say the rows are at an angle of 60 degrees to one another. In that case a distance of 5 ft. between the bushes gives a number of plants to the acre about equal to that obtained with 4½-ft. planting.

Careful hoeing is needed from the very early days of the plantation, and systematically for all subsequent years. This is not only necessary to keep down the weeds, but to open the soil. In Assam, deep hoeing (8 in.) is done at the commencement of the dry weather. This prevents the surface caking; and from four to six light hoeings (3 to 4 in.) are given throughout the growing season at intervals of six weeks. On old forest land, manuring may not be necessary for some years; but sooner or later the restoration of the soil, so as to preserve its yielding capacity, becomes urgent. Cattle manure and the sweepings of the factory and its labour residences are usually applied before the first hoeing of the season. In default of a sufficient supply of that so-called farmyard manure, oilcake has given the best results. In Ceylon, superphosphates and basic slag have been used. Recently much advantage has been obtained by green manuring, especially the cultivation of the Indian bean *Phaseolus Mungo* and other wild or cultivated plants of the pea family.

Pruning in all the Indian plantations is an annual operation deemed of the utmost importance, and which calls for special knowledge. It is usually carried out between December and March—the non-growing season. In other tea areas, as for example in Japan, pruning, if not actually neglected, is only spasmodically resorted to. After the seedlings have been in their permanent positions for six months to one year they are cut down, in December to January, to

some 6 to 8 in. above the ground. In consequence, each plant throws out from three to four shoots, and these are allowed to grow for two years before being again interfered with. When three years old they are cut back to 14 to 18 in. After this, each year's pruning will be at a point 1 to 2 in. above the previous (light pruning) until the yield begins to decline, when it again becomes necessary to prune back to from 12 to 15 in. above the ground (heavy pruning, as this is called). At a still later stage (but only after many years' cultivation), if the bushes are found to be once more giving a decreasing yield, a still more severe pruning may become necessary (collar pruning, as it is called), viz. down to the level of the ground. The age of the tea bush is accepted as from forty to sixty years. But the extent and necessity for pruning depends very largely on the invigorating or leaf-producing property of the environment. With plantations in high altitudes or in temperate countries, growth may be so slow as to render pruning only occasionally necessary. A high degree of pruning, such as that described, only prevails in the plains of Assam, Cachar, the Duars, &c., where the yield may be more than twice that of the hill plantations, for example, of Darjeeling and Kangra.

When the tea has been pruned new shoots are formed, and after two or three months these are 9 in. long and contain at least six leaves. The bushes are then 'tipped', as it is called; that is to say, from all the shoots in the centre of the bush, the terminal bud and the stalk carrying one or two leaves below it, are removed. The shoots on the circumference may not be then ready for tipping, and should not be interfered with. Tipping is not done to get a first yield of leaf, but in order to secure a required condition of flushing. Secondary shoots at once spring from two or three of the buds, in the axils of the leaves remaining on the shoots. It is a good plan to furnish the pluckers with a stick of a certain length, and to direct them to pluck no shoots shorter than the length of the stick from the ground upwards to the tips of the shoots. After three weeks the secondary shoots will be ready for plucking, and the topmost two leaves and the bud of each can now be removed, thus leaving very possibly but two leaves below. The expert plucker does not pull off, but nips off (by the pressure of the thumbnail against the forefinger), the tender tips of the shoots. This brings about another flushing, when again two leaves and the unopened bud are plucked off, leaving but one leaf below. This process of flushing and plucking is continued throughout the season, as a rule from six to eight flushings being obtained, not counting the initial tipping. At first the flushings and pluckings coincide, but in time the amount of leaf produced is too great for this, and the bushes are then systematically plucked every seven to nine days, that is to say, each bush may be plucked from twenty to thirty times during the season. It will thus be seen how essential it is that the first shoots (above the pruning) should be allowed to grow till they possess at least four perfect leaves below the point of first tipping, since upon the buds left on these shoots depends the power of subsequent flushing. Plucking commences in March, but July, August, September, and the first half of October are the months of greatest yield. Plucking ceases by the middle of December. The yield at each plucking, on healthy tea, may be 120 lb. of green leaf to the acre, giving about 30 lb. of tea. The garden comes into bearing as follows: A small yield may be secured during the second year of growth; by the third, 150 lb. per acre can be obtained, and progressively till the sixth, when the garden should be in full bearing, and then yield from 400 to 1000 lb. to the acre.

Coarse-leaf plucking does not prevail in India. All tea is made from the two topmost leaves and the terminal bud of the young shoots. As soon as possible the leaf is carried to the withering-house, where it is spread out on trays, assorted within a cool place, and in such a way as to secure a rapid withering. In cold localities it is found necessary to force in heated air, but in warm districts fans, driven by steam, cause the ordinary air to move freely over the trays. When the leaf has become flaccid it is ready for the next operation, and is accordingly carried to the rolling machine, where it is rolled under pressure. This breaks the cells of the tissue and presses out the leaf juice. When the juice has been brought in contact with the air, the leaf is ready for the further stage, viz. fermentation. If it is intended to produce black tea this is essential; but if green tea be required no fermentation is necessary, and in that case the leaf is usually subjected to a dry heat, sufficient to kill the germs of fermentation before being rolled. It is then rolled, and is at once fired and dried off before any fermentation has been set up. But with black tea there is no danger in protracted rolling, and, in fact, fermentation has usually commenced before the rolling has been finished. In consequence, the leaf changes colour to brown and assumes its characteristic smell. This is, in fact, the commencement of the fermentation, which in the manufacture of black tea must be continued for a period of from two to six hours after rolling has been finished. For this purpose the rolled leaf is spread out on tables or on a specially prepared floor, is covered over with damp cloths, and kept in the dark. It then turns almost black, and takes on the characteristic smell of made tea. At this stage it must be dried off as quickly as possible; and for this further process special machinery has been invented, to take the place of the open pans formerly used by the Chinese. The rolled leaf, spread out on trays, is carried gradually into a hotter and hotter atmosphere, through a chamber permeated by hot dry air, so that the wet leaf (whether green or black) goes in at one end, and comes out at the other as dry tea. It is then sifted, and thus graded into 'Orange Pekoe', 'Pekoe', 'Souchong', 'Congou', 'Broken Leaf', or 'Dust'. These various grades depend on size; the unopened buds and leaf tips fall mainly into the fine Orange Pekoe; hence high-priced teas are not the produce of special plants nor of skill in manufacture, so much as of the mesh in the sieve

that has separated them. From the sifters the tea passes direct into the boxes placed for its reception, and when the desired weight has been obtained the lead lining is at once soldered down, for it is a matter of the greatest importance to prevent the leaf getting damp and thus setting up destructive fermentation (like that which converts wine into vinegar), and the soldering down retains in addition the aroma of the tea—an important result.

The most significant lesson of the story of the progression of tea, manufactured on the Indian method, may be said to be the victory of quality, purity, and cheapness, through machinery and scientific agriculture, over antiquated and obstructive methods of hand labour.

[G. W.]

Teak Wood is the timber furnished by the Teak tree (*Tectona grandis*), a large and lofty tree belonging to the nat. ord. Verbenaceæ, which grows sporadically in Southern India, Burma, Siam, and Java, but has its finest development in Burma. The largest log known to have been extracted measured 82½ ft. long by 10 ft. mean girth (Shweli forest, Burma). If protected against jungle fires, teak is of very rapid growth at first (70 ft. high and 12 to 15 in. girth at breast-height in 18 to 20 years), but takes from 150 to 160 years in moist forest up to 180 to 200 in dry forest to attain the mature dimension of 7 ft. girth measured at 6 ft. above ground. Teak wood is moderately hard, and strongly scented with an essential oil (preservative of iron and steel, hence its special value in shipbuilding), dark-golden-yellow when freshly cut, but turning brown, then dark-brown, and finally almost black with age. The annual rings are marked with one or more lines of regularly-arranged pores, often set in a belt of loose tissue; but in the rest of the wood the pores are scattered, scanty, sometimes subdivided, and variable in size. The medullary rays are fairly broad and numerous, and give a handsome silver grain to boards cut radially. When thoroughly seasoned its average weight is 45 to 50 lb. per cubic foot, while its coefficient of transverse strength varies from 600 to 800, and its modulus of elasticity from 4000 to 5000. Felled green, teak hardly floats; hence trees marked for extraction are killed or 'girdled' by cutting entirely through the narrow ring of white sapwood and well into the brown heartwood, and leaving them to season on the stump before felling and extracting them by floating down the rivers. Each tree gives on the average about 1½ log, and logs average about 60 to 70 cu. ft. Teak wood is the chief timber export from our Indian Empire, but it is also very largely used in India for house- and shipbuilding, bridges, furniture, &c., as the essential oil contained makes it very durable. Even with the introduction and increase of iron shipbuilding, the demand for teak wood has been constantly rising, as also its cost per cubic foot. Timber of large size from the virgin forests is now becoming very scarce; but in Burma careful measures are taken to prevent the teak forests from being overworked, and both in Burma and in Java the large plantations that have been continuously made during the last forty years will in time provide ample supplies for future use.

[J. N.]

Teats, Diseases of.—Small injuries, and comparatively mild diseases like cow pock, are of much more serious import than would appear to any but those having practical acquaintance with animals. No pimple or abrasion, no slight chap or wound however insignificant, should be neglected. Chaps and cracks are of common occurrence in winter, and are chiefly caused by leaving the teat cold and wet after the stimulation inevitable in stripping the cow. The calf, the lamb, and the pigling, with sharp and early developed nippers, bring about similar ills to their mothers; besides which the smaller animals and those with pendulous udders receive injuries from brambles and other wounding materials present in rough pastures. The specific eruptions are referred to under PUSTULATION, but the general treatment for eruptive or other sores may be considered here. It is important that they should be sterilized with an antiseptic, and softened by an emollient which shall prove harmless if accidentally introduced into the milk pail or conveyed to the stomach of the suckling. Such a lotion may be made by dissolving 1 oz. of boracic acid and 3 oz. of glycerine in 40 oz. of water, of which half can be poured into a wide-mouthed pickle bottle of 20-oz. capacity, and this taken to the cow or other large animal, at blood heat, and used as a bath. After a few minutes' immersion the teat should be drained but not dried, so that a glycerinated film forms a protective as well as softening agent. This method is recommended in a general sense for applications to teats. Only severe wounds should be sutured or stitched together, as constriction is the chief danger when healed, and the longer process of filling up the space by granulation is less likely to result in stricture. The above bath will be suitable. Leaking teats are generally caused by injury to the delicate sphincter muscle which guards the entrance. The forcing of milk by heavy-fisted men operating with dry hands upon heifers is a common cause; the more delicate handling of a maid with moistened fingers would not have had such a result. Overstocking is another cause. The muscle sometimes recovers in a cow long dried off, but where the fibres are actually ruptured there is either the permanent partial paralysis which permits leakage, or a constriction due to the cicatrix and necessitating the use of the syphon. A strong calf will often overcome a stubborn teat. So-called blind syphons, if carefully used, may serve to prevent leaking, and we have known thin rubber bands successfully employed, but they need to be carefully judged as to the degree of pressure, or mischief may be done. 'Peas' or little bodies inside the channel of the teat obstruct the flow of milk, and are dealt with by pushing aside by the syphon, or excision by twisting within the canal an instrument called a papillatome, which is very like an ordinary milk syphon with a cutting edge—a substitute the writer has found very useful. All that is needed is to file one side. The operator must boil or otherwise sterilize the instrument and

grasp the teat with one hand while getting the cutting edge into contact with the pea-like body. No outward application will influence these growths, which on examination outside are found to have had but a slender attachment in most cases. Warts are a frequent teat trouble. Those which come in great numbers and have the appearance of a black oat (or a white one on some cows) may be individually strangled, or removed by the slower process, namely, the daily application of salicylate collodion. [H. L.]

Teazle, a biennial plant grown for its flower-heads, which are used in the manufacture of woollen cloth. See art. DIPSACUS.

Tedders and Tedding. See arts. HAYMAKING and HAYMAKING MACHINERY.

Teeswater Cattle. See art. SHORTHORN CATTLE.

Teeth, Defects and Diseases of.— Diseases and irregularities of the teeth of our domesticated animals have not perhaps received so much attention as they deserve, when it is remembered that defective mastication has far-reaching effects upon the health and comfort of the animals. Among the irregularities in teething may be mentioned delayed eruption of the teeth, or impediments to their appearance above the gums. As with infants, this trouble gives rise in calves, pigs, and dogs to febrile disturbance and to fits, but colts are rarely observed to have trouble with their primary teeth. The milk teeth, as the primaries are often called, are not such frequent subjects of trouble as the permanent ones, and the sucking period may be passed through successfully with such a serious defect as congenital absence of all the molars.

Fig. 1.—Tooth-rasp

Numerical excess or deficiency of teeth is an evil. Crowding and an irregular arrangement almost certainly go together. When there are too many incisors in the colt they will generally be noticed, and the least desirable ones should be extracted, when it will be found that the others come into line without the denture or contrivances prescribed for children. These supernumerary teeth sometimes appear far back from the others in the palate, or placed outside the ordinary row, and interfering with the lips or cheeks and injuring the tongue. Numerical excess leads to retention of particles of food, which decompose and excite pain and irritation. Mastication is difficult, and digestion suffers. More or less dribbling of saliva and dropping of the food (quidding) is a prominent symptom of this and some other disorders of the teeth and tongue, and should at all times receive attention. Deficiency in the number of the teeth hinders grazing and mastication, and if the interdental spaces are abnormal there is also a tendency for the food particles to get fixed between them. Disparity of length is one of the commonest troubles in horses, and is not frequently overlooked in aged cows. A molar tooth standing up above the level of its fellows precludes grinding, and prevents those lateral movements essential to thorough mastication. The marginal irregularities are easily reduced by the rasp, if undertaken early, but an offending tooth standing up above the level must needs be cut with a special chisel and made to match its fellows. An overgrown tooth should not in ordinary circumstances be extracted, for reason which will be presently stated in connection with caries. It is the outer edge of the upper molars and the inner one of the lower that are disposed to grow ragged, because they miss the attrition which keeps the tables level. The good horsemaster will examine the teeth, particularly the molars, at intervals throughout the animal's life. As age advances, the lateral movements are not so free, and marginal irregularities may be either cause or effect. Periodical rasping is of much value. In the case of young stock intended for food, we have chiefly to look for temporary molars caught between the permanent ones and interfering with mastication, although frequently having no very strong attachment, or not enough to resist the action of a pair of pliers in the hands of a stockman. The front teeth (incisors) of horses and dogs are not infrequently broken by falls—an accident which rarely happens to ruminants or to pigs, owing to the different arrangement of the teeth, the thick lips, or projecting snout. The molars are occasionally fractured by foreign bodies, as nails and stones which have been accidentally taken with the food. Incisors are generally snapped off transversely or obliquely, but molars are apt to split downwards. The broken incisor need not necessarily decay or cause any lasting pain, but the grinder split down into the fang gives rise to toothache, as is quite evident by the animal's behaviour. The food enters the socket (alveolus), and sets up those inflammatory conditions and fetid breath which accompany overcrowding and abnormal interdental spaces. A tooth broken vertically should be extracted. A transverse fracture of an incisor may be treated by breaking it off close to the gum which will grow over it. Not only does food accumulate in a fractured molar, but the tooth decays and emits a particularly offensive odour. The changed colour is evidence of decay, the tooth being yellowish-black, and quite unlike a normal grinder.

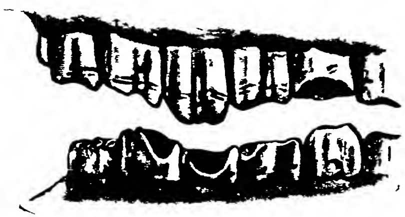
Caries.—Decayed teeth are not a common trouble. Actual caries as seen in the human subject is quite rare among stock. When met with in farm animals it is generally due to injuries, and the chronic inflammation of the gums caused by lodgment of food or morbid conditions of the jawbone. The neck of the tooth is the commonest seat of decay, but it may commence from the fang or the crown. In the horse the fourth molar has been observed to be the most frequent subject of caries. The process of decay is usually slow, except where it commences at

DEFECTS AND DISEASES OF TEETH

A

B

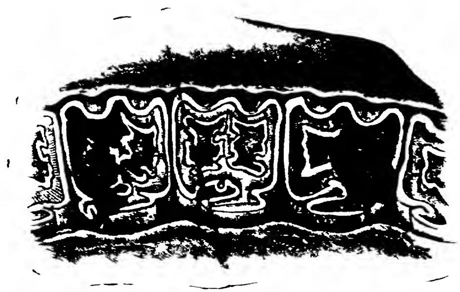
C



UNDULATING IRREGULARITIES OF MOLARS

A, Right side of upper jaw showing excavation of the bone and abnormal wear of the inner surface of the teeth

B Lower jaw showing corresponding teeth similarly worn on the outer side as in fig. C and excavation of the jaw by the downward projection of the upper molars



CARIES

PARROT MOUTH

TEETH OF CRIB BITER

the neck of the tooth. In the latter case it soon appears dead, and generally becomes loose. The decayed fang is apt to give rise to abscess in the jaw and outward swelling. Decay commencing from the side is what might be expected when the causes are remembered. If the crown is first or only affected, or the side is not decayed below the gum, we are afforded an opportunity of drilling out the necrosed material and filling up the space with a good amalgam or other hard stopping. Gutta percha has been successfully employed. The quantity of gold required precludes its use. In horses and in ruminants the removal of a tooth is followed by growth of its opponent in the opposite jaw, and if not checked is liable to pierce the tissues (see GLEET, NASAL). The dental troubles of dogs call for some notice. Overcrowding in the miniature Pomeranian is sometimes to be seen in the exaggerated form of a complete double set of both incisors and molars. All puppies should have their teeth examined for supernumeraries, which are easily removed. Before maturity is reached, tartar begins to accumulate upon the tushes, and in

A

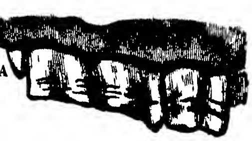


Fig. 2.—Wolf's Tooth (shown at A)

most dogs incrustations of this substance increase on all the teeth as years go on, until the gums are pushed back, the salivary fluid enters the alveolar cavities, and a chronic periodontitis is established: the teeth are loose, the gums inflamed and painful, and the breath offensive. If scaled twice a year this may be prevented. Decayed or loose teeth should always be extracted. *Parrot mouth* is explained in the Plate (fig. 4). It occurs in horses and dogs. It hinders a horse from grazing, although it will be remembered that he seizes his food with the lips; and the subjects of it are apt to fall away if turned out to grass. In the stable, horses with parrot mouth learn to lip and tongue their food into a position where the molars can deal with it, and, like the subjects of fractured jaw, acquire the art of sucking up soft food as pigs do. In bad cases the incisors of the lower jaw come in contact with the palate and inflict injury. The remedy is to file them down at recurring intervals. *Crib biting* results in the wearing down of the incisors, more particularly on the outer edge, but it does not produce any actual disease of the teeth. *Wolves' teeth* in horses are the subject of some superstition, many persons believing that they lead to blindness and are a cause of shying. They are vestigial remains or imperfect reproductions of what was once the seventh molar in equines. When the two first molars are cut, between the second and third year, they are commonly pushed out. They have not proper fangs, and are easily extracted with ordinary pincers if the mouth is gagged or held open by another person. In case of accident to the tushes, the general recommendation to extract the split tooth must be accepted with reserve. If loose it will be possible, but in the usual way these teeth have very long fangs with some little thickening about the middle, and a slight bend, while they are inserted into an alveolar cavity but thinly covered by bone. This anatomical arrangement makes it much easier to break the jaw than extract the tush. In old dogs they eventually become loose. In the boar there is a modified twist within, comparable with that outside, and this makes it advisable to break off rather than attempt the extraction from a savage animal whose tushes have grown long. A smart blow with a hammer has the merit of effecting the purpose with less risk of fracture of the jaw than would accompany any attempt at extraction. [H. L.]

Telegony.—Breeders have long believed that offspring inherit traits from a previous mate of the dam. When this happens, it is said the offspring have 'thrown back', owing to their dam having been 'infected' by the former mate. For example, it is sometimes alleged that a Percheron foal out of a mare from which mules have been bred sometimes, in one or more points more closely resembles the previous ass sire than the actual Percheron sire. This throwing back to an unrelated previous mate of the dam is now known as telegony. Though it is extremely difficult to imagine how a mare or other female animal can be so modified that a previous mate may count almost as much as the actual sire, naturalists as well as breeders until a few years ago believed telegony to be well within the bounds of possibilities. Herbert Spencer said he had evidence 'enough to prove the fact of a previous sire asserting his influence on a subsequent progeny'. Darwin, Agassiz, Carpenter, and others were inclined to believe in the 'infection' doctrine, and even Weismann admitted that the widespread belief 'may be justifiable and founded on fact'. Weismann, however, added that the tradition could only be confirmed and telegony proved by methodically conducted experiments. It is assumed that 'infection' is due to material from the fœtus eventually reaching and modifying the germ cells of the dam, or to sperm cells of the first mate penetrating but not actually fertilizing unripe germ cells near the surface of the ovary. If, as some say, telegony occurs in birds, it must be due to the unused germ-plasm of the first mate being incorporated in the unripe ova. In addition to assuming that female mammals and birds are liable to be 'corrupted', some breeders assume that a male may be 'infected' and be the means of transferring characters from one breed to another. Apparently no one has yet explained how a Jersey bull might acquire the peculiarities of the Galloway breed and subsequently transfer them to members of his own breed.

If there is such a thing as 'infection', it follows: (1) that pure-bred females are liable to be 'corrupted' when they produce offspring to males of a different race or breed; and (2) that cross-bred and inferior females, if first mated with a high-class sire, may subsequently pro-

duce superior offspring to inferior sires. Breeders of dogs have adhered more firmly to the 'infection' doctrine than have breeders of horses, sheep, or cattle. Some years ago almost every dog-breeder believed that he knew of several undoubted cases of 'infection'; but since Sir Everett Millais asserted that after nearly thirty years' experience (during which he made all sorts of experiments) he had never seen a case of telegony, fanciers have not been so certain that 'infection' is common; some even allege that there is no such thing as telegony.

The writer made numerous experiments with dogs without obtaining any evidence in support of telegony, and he has heard of many undesigned experiments which, though affording excellent opportunities for 'infection', failed to support the belief in telegony.

On the Continent and in America many believed that mares used for breeding mules were so saturated with the characteristics of the ass, that they were incapable of producing a pure foal to a stallion of their own breed. Darwin mentions 'that farmers in South Brazil . . . are convinced that mares which have once borne mules, when subsequently put to horses, are extremely liable to produce colts striped like a mule'. On the other hand, Baron de Parana of Brazil recently wrote: 'I have many relatives and friends who have large establishments for the rearing of mules, where they obtain from four hundred to a thousand mules in a year. In all these establishments, after two or three crossings of the mare and ass, the breeders cause the mare to be put to a horse, yet a pure-bred foal has never been produced resembling either an ass or a mule.' The writer failed to find any evidence in the West Indies or in Mexico that mares used for mule-breeding are liable to be 'corrupted'.

Those who believe in the doctrine of 'infection' rest their case mainly on experiments made by Lord Morton during the early part of last century. A chestnut mare imported from India, after having a quagga hybrid, produced to a black Arabian horse a richly striped filly with (according to the stud groom) a short stiff upright mane. The writer has in his possession two Arab-pony crosses more richly striped than the filly out of Lord Morton's chestnut mare; hence the stripes on the filly cannot be regarded as evidence of 'infection'.

As it happens, the evidence from the mane is also far from convincing, for in a drawing of the filly in question by Agasse, a very reliable animal painter, the mane is represented as lying to one side of the neck. Even an upright mane in the filly would not supply irrefragable proof of 'infection', for in a bay Arab mare of the 'Siwalik' type bred by the writer the mane in spring is short and upright. Further, in a Welsh-Shetland pony and in a Faroe Island pony the mane is only long enough to arch to the side of the neck as in zebra hybrids.

Some years ago the writer repeated as accurately as possible Lord Morton's experiment. Seventeen mares, after having hybrids by a Burchell zebra, produced twenty-three foals by Arab and other pony stallions. Not one of these foals afforded evidence of 'infection' by the richly striped hog-maned previous sire. Experiments with sheep and cattle, rabbits and mice, fowls and pigeons, like those with dogs and horses, entirely failed to prove that the first sire has any influence on offspring obtained by subsequent sires. Breeders may hence in future disregard the 'infection' doctrine. [J. C. E.]

Temperature.—Two bodies are said to be at the same temperature when, on bringing them into contact, no heat passes from one to the other. Ordinary observation is apt to give very false ideas of temperature in many cases. For instance, if an iron implement with a wooden handle is left out all night in cold weather, the iron part will seem much colder to the touch than the wood, because the hand will part with its heat more quickly to the good conductor, the iron, than to the poor conductor, the wood. Temperature has therefore to be determined by the properties of inanimate substances. Two standard temperatures in common use are that at which ice melts and that at which water boils under a standard barometric pressure. When a quantity of finely powdered ice is allowed to melt slowly with constant stirring, the ice itself and the water surrounding it are in equilibrium as to temperature, so that this remains unchanged, the heat absorbed from the environment being used up in melting the ice; consequently a thermometer immersed in the mixture shows a steady constant temperature, which is reckoned as 32° on the Fahrenheit scale and 0° on the Centigrade. When water is boiling in an open vessel with the barometer standing at the standard height, the water and the steam are at an identical temperature, which is reckoned as 212° on the Fahrenheit scale and 100° on the Centigrade. These two points are fixed, it will be seen, entirely by the properties of water, being the temperature at which solid water is in equilibrium with the liquid phase, and that at which the pressure of water vapour is equal to the standard pressure of the atmosphere. In the Centigrade scale this interval is divided into 100 equal parts or degrees, marked from 0° to 100°; whilst in the Fahrenheit thermometer the interval is divided into 180 degrees, which are numbered from 32° to 212°. It follows that 0° C. = 32° F., and 100° C. = 212° F. Hence the rule: to convert Centigrade degrees into Fahrenheit, multiply by 1·8 or $\frac{9}{5}$ and add 32. To convert Fahrenheit degrees into Centigrade, first subtract 32, then multiply by $\frac{5}{9}$ or divide by 1·8. A more convenient formula is based on the fact that $-40°$ C. is the same as $-40°$ F., therefore to any temperature above zero add 40, then multiply by 9 and divide by 5 to convert degrees C. into degrees F., or multiply by 5 and divide by 9 to convert degrees F. into degrees C., as the case may be, and finally subtract 40. Thus, to convert 20° C. into Fahrenheit, $20 + 40 = 60$, $60 \times 9 = 540$, $540 \div 5 = 108$, $108 - 40 = 68$. The required answer is 68° F. To convert 59° F. into Centigrade, $59 + 40 = 99$, $99 \times 5 = 495$, $495 \div 9 = 55$, $55 -$

40 = 15. The Centigrade equivalent of 59° F. is 15° C. It is convenient to remember that 10° C. = 50° F., 15° C. = 59° F., 20° C. = 68° F., 30° C. = 68° F., 50° C. = 122° F.

Absolute temperature is based on the properties of gases, and assumes the existence of an absolute zero, which is about − 273° C., that is to say, 273 Centigrade degrees below the melting-point of ice. The volume of a given mass of gas is proportional to its temperature on the absolute scale. [C. M. L.]

Temperature in Animals.—In the lower animals (including Fishes, Amphibians, and Reptiles) the temperature of the body varies with the surroundings, being usually not more than a fraction of a degree above the external temperature. Such animals are known as poikilothermal or cold-blooded. On the other hand, in Birds and Mammals the body temperature is to a large extent independent of the temperature of the surrounding medium. These are called homoithermal or warm-blooded animals. Mammals which hibernate (*e.g.* the hedgehog) are, however, an exception, since in these the body temperature sinks during the winter sleep, when they behave like poikilothermal animals.

The mechanism by which in a warm-blooded animal the body temperature is kept almost constant resides in the skin and the bloodvessels and nerves which supply it. When the air or surrounding medium is warm, or when the heat produced in the body is increased by muscular exertion, the bloodvessels are dilated, the skin is flushed and hot, and a considerable amount of heat is diffused from the surface of the body. If, however, the surrounding medium is cold, the vessels of the skin contract and there is less heat given off from the body. On the other hand, if the external temperature is very considerable, or if there has been severe muscular exercise, another regulating mechanism is employed, namely, the secretion of sweat or perspiration. This fluid, which consists very largely of water, with a small amount of salts and organic matter (serum and fat), is secreted by little glands in the skin. These glands are supplied by nerves which are excited by a rise of temperature and so control the formation of sweat. As the sweat evaporates from the skin the temperature of the body is lowered. In these ways an approximately even temperature is maintained. But if the heat-regulating mechanisms are disturbed, as occurs during fevers, the temperature may rise very considerably above the normal. A covering of hair or clothing helps to keep the body warm, because it lessens the diffusion of heat from the surface. The temperature of the body is not absolutely uniform, that of the skin being lower than the internal temperature. For clinical purposes the temperature should be taken either in the vagina or in the rectum. Both in Man and other warm-blooded animals there is usually a slight diurnal variation in the temperature, which is higher in the evening than in the morning. This variation depends upon the daily change in the metabolism, which is lessened during rest but increased during activity, the oxidation of food and the performance of muscular work being the main sources of bodily heat.

The average normal temperatures of Man and various domestic animals are approximately as follows:—

Man	37° C. (98·4° F.)
Horse	38·1° C. (100·6° F.)
Cow	38·7° C. (101·8° F.)
Sheep	39·95° C. (104° F.)
Pig	39° C. (103·3° F.)
Dog	38·4° C. (101·3° F.)
Chick	42° C. (108° F.)
Pigeon	42° C. (108° F.)

[F. H. A. M.]

Temporary Pastures. See art. PASTURES.

Tenancy, Determination of.—ENGLAND.—Apart from surrender or merger of the lease, the usual modes in which a tenancy is determined are: (1) by efflux of time, or the happening of some event on which the duration of the lease is made conditional; (2) by notice to quit; (3) by forfeiture.

1. *Efflux of Time.*—Where a lease is for a time certain, or until some specified event occurs, no notice to quit is necessary, except where an option is reserved to determine the lease at an earlier period on giving notice. In such cases the notice stipulated for must be given.

2. *Notice to Quit.*—If the tenancy is from year to year, in the absence of special agreement, six months' notice must be given, unless some other term, longer or shorter, has been expressly stipulated for, in which case the stipulated notice must be given. But in the case of agricultural holdings it is provided by the Agricultural Holdings Act, 1908, that where a half-year's notice, expiring with a year of tenancy, is by law necessary and sufficient for the determination of a tenancy of a holding from year to year, a year's notice so expiring shall be necessary and sufficient for such determination, unless the landlord and tenant agree *in writing* that the Act shall not apply, in which case a half-year's notice shall be sufficient. The notice is usually, and ought always to be, in writing, though it has been held that, apart from express stipulation, this is not essential. It may be given by either landlord or tenant in his own name or through his authorized agent, provided the agent has sufficient authority to that effect when the notice is given. No special form is necessary, but the notice must extend to all the premises leased, and a notice extending to only a part is bad. This is, however, subject to the exception that, in the case of agricultural holdings, it is provided by the Agricultural Holdings Act, 1908, sect. 23, that, 'Where a notice to quit is given by the landlord of a holding to a tenant from year to year, with a view to the use of land for any of the following purposes:—

(1) The erection of farm labourers' cottages or other houses with or without gardens;
(2) The provision of gardens for farm labourers' cottages or other houses;
(3) The provision of allotments for labourers;
(4) The provision of small holdings as defined by the Small Holdings and Allotments Act, 1907;
(5) The planting of trees:

(6) The opening or working of any coal, ironstone, limestone, brick earth, or other mineral, or of a stone quarry, clay, sand, or gravel pit, or the construction of any works or buildings to be used in connection therewith;

(7) The making of a watercourse or reservoir;

(8) The making of any road, railway, tramroad, siding, canal, or basin, or any wharf, pier, or other work connected therewith;

And the notice states that it is given with a view to any such use—

it shall, by virtue of this Act, be no objection to the notice that it relates to part only of the holding.'

The notice may be served on a Sunday, and need not be served personally. It is sufficient if it be sent by post, or delivered at the dwelling-house into the hands of a servant, whose duty it is to deliver it to the person for whom it is intended. It has even been held to be sufficient to leave the notice in a letter-box or push it under the door, but such methods of service are obviously not to be recommended. Personal service or by registered letter obviates all difficulties as to proof of due notice.

3. *Forfeiture.*—A lease may be determined by entry or ejectment by the landlord on account of the tenant's breach of some covenant in the lease, or implied thereunder, but only if there be a condition in the lease providing for such re-entry. Thus the tenant's bankruptcy or failure to make due payment of the rent may be made the grounds of forfeiture. In the case of non-payment of rent a formal demand for payment by the landlord is a condition precedent, unless the lease, as is usual, provides for re-entry without the necessity for a formal demand. Moreover, if half a year's rent is in arrear, and no sufficient distress is to be found on the premises, a formal demand is rendered unnecessary by the provisions of the Common Law Procedure Act, 1852 (15 & 16 Vic. c. 76, sect. 210).

Death, or Destruction of the Premises.—A lease is not terminated by the death of either the landlord or tenant, the rights and obligations thereunder vesting in their respective personal representatives.

Destruction of the premises does not of itself determine the tenancy. But in leases it is usual to stipulate that the destruction of the buildings by fire or other inevitable accident shall absolve the tenant from his obligation to pay rent.

Holding Over.—Where a tenant, at the termination of his lease, does not peaceably hand over the premises to the landlord, he becomes liable in payment of double the yearly value of the premises for the time during which he holds them over; though this is not necessarily equivalent to double rent it is generally estimated as such. But, in order to incur this liability, (1) he must be holding over the premises wilfully, *i.e.* without 'a fair and reasonable claim of title'; and (2) there must be a demand made and notice in writing given by the landlord for delivering the possession. A notice to quit previously given, if in writing, is a sufficient compliance with this condition.

SCOTLAND.—Apart from voluntary renunciation of the contract, the usual modes in which a lease is terminated are: (1) by efflux of time, or by the occurrence of a break in the lease in favour of either landlord or tenant or both, advantage of which is taken; (2) by the occurrence of an irritancy, statutory or conventional; (3) by destruction of the premises.

1. *Efflux of Time, &c.*—The tenant is bound to remove from the premises at the period fixed for the termination of the tenancy in terms of the lease. This obligation is usually made an express term of the lease. If there is an express written obligation to this effect either contained in the lease or in some other document, and if the obligation is dated within the year of removal, no notice to quit is required. If, however, the obligation is dated beyond the year of removal, or if there is no such obligation contained in the lease, then notice to quit is in all cases necessary to enable the landlord to eject the tenant. Apart from stipulation, the shortest notice permissible is forty days before the term of removal. Usually, however, the period of notice is expressed in the lease, and if so the term mentioned must be adhered to. It is to be noted that where the intimation has to be given a certain number of days before the term of Whitsunday or Martinmas, the date from which the period is computed will be the 15th of May or the 11th of November as the case may be, since the provisions of the Removal Terms (Scotland) Act, 1886, do not affect the legal terms for the purpose of calculating the dates at which notice of removal requires to be given. Failing due notice having been given, a lease for a year or a longer period will be renewed by tacit relocation for one year, and thereafter from year to year until proper notice has been given by either party to the lease. A lease for a shorter period is prolonged for the like period, and so on from period to period till notice be given. In the case of agricultural holdings, it is provided by the Agricultural Holdings (Scotland) Act, 1908, sect. 18, as follows: (1) Notwithstanding the expiration of the stipulated endurance of any lease, the tenancy shall not come to an end unless written notice has been given by either party to the other of his intention to bring the tenancy to an end—

(*a*) in the case of leases for three years and upwards, not less than one year nor more than two years before the termination of the lease; and

(*b*) in the case of leases from year to year, or for any other period less than three years, not less than six months before the termination of the lease.

(2) Failing such notice by either party, the lease shall be held to be renewed by tacit relocation for another year, and thereafter from year to year.

It is believed that in the case of a lease renewed by tacit relocation the notice which will be requisite to bring it to a termination is six months. In the case of a break being stipulated for in the lease, it is invariably the case that notice of the intention to avail of the break is conditioned in the lease, and in such circumstances the notice stipulated for must be given.

2. *Irritancies.*—An irritancy is the determination of a lease on account of the breach of a condition inferring the right to bring the lease to an end, either by virtue of the common law or by reason of a special condition to that effect in the lease. Such irritancy may be either legal or conventional.

(1) *Legal Irritancies.*—At common law an irritancy is incurred by the non-payment of rent for two successive years, and this irritancy has been made statutory by the Act of Sederunt of 1756. But in the case of agricultural holdings the law is now regulated by the Agricultural Holdings (Scotland) Act, 1908, sect. 17, which provides as follows:—

(*a*) When six months' rent of the holding is due and unpaid, it shall be lawful for the landlord to raise an action of removing before the sheriff against the tenant, concluding for his removal from the holding at the term of Whitsunday or Martinmas next ensuing after the action is brought; and, unless the arrears of rent then due are paid or caution is found to the satisfaction of the sheriff for the same, and for one year's rent further, the sheriff may decern the tenant to remove, and eject him at such term in the same manner as if the lease were determined, and the tenant had been legally warned to remove:

(*b*) A tenant so removed shall have the rights of an outgoing tenant to which he would have been entitled if his lease had naturally expired at such term of Whitsunday or Martinmas.

(2) *Conventional Irritancies.*—An irritant clause may be made a condition of the breach of almost any obligation in a lease provided it is inserted in the deed, but the most usual irritancies are those which apply either to non-payment of rent or to the bankruptcy or insolvency of a tenant. In the case of non-payment of rent the object of inserting an express irritancy is to enable the landlord to eject his tenant at an earlier period than he could apart from agreement. But in the case of agricultural subjects, this object is to all intents and purposes attained by the clause above quoted, although a conventional irritancy may be of use in the case of other subjects.

It is the usual practice in all leases to insert a clause entitling the landlord to resume possession of the lands in the event of the bankruptcy or declared insolvency of the tenant.

Purgation.—In the case of all legal irritancies, it is a rule of law that the party in breach is entitled to purge the irritancy by making payment of the arrears due and finding caution for a portion of the rent to become due, provided this be done before extract of the decree. After extract has been taken, purgation comes too late. In the case of conventional irritancies, on the other hand, it is a settled rule of law that they cannot be purged, although the Court may step in to prevent the misuse of the power.

3. *Destruction of the Premises.*—In the case of total destruction of the premises the lease comes to an end. Where the destruction is partial and the landlord offers to restore, it is a question depending upon the circumstances of each case whether the tenant is entitled to abandon the lease or bound to continue in the tenancy subject to an abatement of rent. See under LEASES.

Death.—The lease is not affected by the death of landlord or tenant, but in the case of agricultural subjects special provision is made for the bequest of the lease by the tenant. See under AGRICULTURAL HOLDINGS ACTS.

Violent Profits.—Where a tenant who has been duly warned to quit the premises continues in occupation of them without title after the expiry of the tenancy, he incurs liability to penal damages, known as violent profits. It is, however, a good defence to a claim for violent profits that the defender was possessing in good faith. In burghs, violent profits are, by custom, estimated as double the rent, but in other subjects as the highest profit which the landlord can prove he could have made either by possessing the lands himself or by letting them to another tenant. [D. B.]

Tenant. See arts. LEASE; AGRICULTURAL HOLDINGS ACTS.

Tenant Farmer.—For the purposes of cultivation the landlord lets out his land to farmers, who are called 'tenants', and the agreement which guarantees the exclusive possession of the farm or holding for a limited time is called a 'lease'. The consideration for which the lease is granted is called the 'rent'. The occupiers of land may be: (1) tenants for life, in which case they cannot be deprived of their farms so long as they live; or (2) tenants on suffrance or tenants at will, in which case the landlord may resume possession of his farm at any time. But more generally tenancies are between these two extremes and are either: (3) from year to year, or (4) for a period of years, probably 15, 19, or 21. The lease for 15 to 21 years—but commonly nowadays with provision for earlier termination, say at the end of 5 or 10 years should either party wish it—is almost universal in Scotland and very general in the north of England, but the yearly tenancy is by far the most common form of land tenure in the majority of the counties in England. The advantages of leases of considerable duration must be obvious both to landlord and tenant, securing as they do, from the point of view of the former, that the places will be properly cultivated, and from the point of view of the tenant that he will have a reasonable chance to secure the fruits of his toil, and a return for his outlay. Many landlords, however, feel that by yearly tenancies they retain more fully the control of their own land, and tenants generally suppose that low rents accompany the shorter and more uncertain agreements. As a general rule, however, it may be said that short leases do not tend to encourage good farming, and there is often only too little inducement for an outsider to covet possession of such holdings, and hence the occupants are left undisturbed.

In England and Scotland there is no 'fixity of tenure' of farms, that is, the landlord has the undisputed right to bring the tenant's occupation of a farm to an end when his lease expires. In Ireland, fixity of tenure was secured to tenants by Land Acts passed in the later

years of the past century. The Agricultural Holdings Act of 1908 (England and Scotland), however, has provided for compensation for disturbance under certain conditions and reservations in the event of a landlord terminating a tenancy where the tenant wished to remain in possession (see art. AGRICULTURAL HOLDINGS ACTS). But some of the expressions in the Act —and especially this: 'Where the landlord of a holding, without good and sufficient cause, and for reasons inconsistent with good estate management, terminates the tenancy'—seem capable of very different interpretations, and an authoritative decision by a Supreme Court will sooner or later have to be got, to show whether the whole clause which provides for compensation for disturbance is more than an illusion. As regards the improvements a tenant may have made on his holding during the currency of his lease—however short—he has compensation fully secured for him. Of this compensation the tenant cannot deprive himself by 'contracting out', and the measure of all such compensation is to be such a 'sum as fairly represents the value of the improvements to an incoming tenant'. [W. B.]

Tenant Right.—In its broadest sense the term 'tenant right' means the right of a tenant to the usufruct of the subject of the tenancy under various conditions, the chief of which is the payment of rent, which in ancient times, in relation to land, consisted of service, a portion of the produce, or money. It is obvious, however, that the complete usufruct of land involves much more than the mere taking of its annual produce; for some degree of security of tenure and a right to the tenant to dispose of or be paid for the fruits of his enterprise and labour not realized at the termination of his tenancy are also necessary.

The earliest example of legalized tenant right of which there is any historical record is to be found in the emphyteusis of the ancient Roman Empire, and it is curious to notice that this tenure embodied the most perfect as well as the earliest example. In his Introduction to Roman Law (Maxwell & Son, London, 1880) the late Professor Hunter defines emphyteusis as 'a grant of land for ever, or for a long period, on the condition that an annual rent (*canon*) shall be paid to the grantor and his successors, and that, if the rent be not paid, the grant shall be forfeited'. The same writer expresses the opinion that this tenure may be traced to the long or perpetual leases of land taken in war granted by the Roman State, and that it speedily recommended itself to corporations, ecclesiastical and municipal, as a convenient method of relieving themselves of the management of their landed estates, and later on to individual proprietors. Maine, in his Ancient Law, ascribes the initiation of the tenure to the Roman municipalities, and subsequently traces another system of tenant right to a further development of the transformation of servility into freedom. He states that the first mention in Roman history of estates larger than could be farmed by a paterfamilias, with his household of sons and slaves, occurs when we come to the holdings of the Roman patricians. 'These great proprietors', he adds, 'appear to have had no idea of any system of farming by free tenants. Their *latifundia* seems to have been universally cultivated by slave gangs under bailiffs, who were themselves slaves or freedmen.' But this system was especially disadvantageous to municipalities, and, accordingly, it is recorded that these corporations began the system of leasing land for a perpetuity to a free tenant at a fixed rent under certain conditions. Later on, the system, as has been stated, was adopted extensively by private landowners, and, in course of time, the tenant, whose relation to the owner had originally been determined by his contract, was recognized by the Prætor as having acquired a qualified proprietorship. The ownership of the grantor of the lease, however, was kept alive by a power of re-entry on non-payment of rent, a right of pre-emption in case of the sale of the tenancy, and a certain control over the methods of cultivation. Subject to these rights, the tenant enjoyed fixity of tenure at a fixed rent, and the power of free sale. The landlord was obliged to accept any purchaser of the tenant right as a tenant, unless he chose to exercise his privilege of purchasing it at the price offered. An alternative transformation of servile tenure to freedom is referred to by Maine as having laid the foundation of the Métayage system of tenancy which still prevails extensively in southern Europe.

It would have been a fortunate thing for this country if the Roman example had been followed when feudal servitude in relation to land was transformed into commercial freedom. The only parallel to the Roman emphyteusis adopted in Great Britain during the period of transformation consisted in the adoption of the copyhold system, which embodied many forms of injustice and some abominations too shameful to mention for generations after its initiation. As to the early farm leases, it was found necessary in the reign of Henry VIII to pass an Act (32 Henry VIII, ch. 28) to prevent the eviction of holders of leases for years, or even for lives, on the deaths of the lessors, which had become a crying abuse. This statute for the first time made leases good in law against the lessors, their wives, heirs, and successors.

Instead of encouraging tenants to improve their farms, by giving them security, the landlords for generations after farm leases became common succeeded in getting laws passed to reduce such security; and even up to the present time the maxim, *Quicquid plantatur solo, solo cedit*, established by the Statute of Gloucester (6 Edw. I), has not been annulled to any considerable extent, except in relation to trade fixtures, including commercial hothouses, and trees and bushes in market gardens and allotments. At one time, indeed, an agricultural tenant was actually prohibited from erecting or improving buildings necessary for farming to full advantage, operations absurdly included under the term 'waste' in legal documents. A later example of the shortsighted policy of landlords while they held the supreme power of making or suggesting the laws of the country,

is afforded by an Act passed in the reign of William and Mary, empowering a landlord to sell goods distrained for rent, which he had previously been entitled only to hold in order to compel personal services. This, however, applied only to a lease in the covenants of which the tenant had assented to such a proceeding; and it remained for an Act passed in the reign of George II to extend this power to all tenancies, thus encouraging the letting of land to tenants-at-will or yearly tenants, who thereafter were greatly increased in number.

There appears to be no definite evidence as to the period in which farm covenants or the custom of the country first secured to an outgoing tenant a claim to obtain from his successor payment for crops left unmatured, manure not applied to the land, fallows, and stacks of hay.

As to the form of tenant right now commonly referred to as compensation for unexhausted improvements, nothing of the kind was established by law in this country before the 19th century, although it was suggested two centuries earlier. Probably the first public advocacy of such a right was that embodied by Walter Blith, one of the best known of the few English writers on agriculture who lived before the end of the 17th century (see art. BLITH, WALTER), in the dedication of the second edition of his English Improver Improved, the first edition of which was published in the first year of the Commonwealth. In the dedication, which was to 'The Right Honorable the Lord Generall Cromwell, and the Right Honorable Lord President, and the rest of that most Honorable Society of the Council of State', Blith asked for the removal of certain 'prejudices', which he described as hindrances to agricultural advancement. His presentation of the subject shows so sagacious an appreciation of the need and value of tenant right that it is well worth quoting *verbatim*, as follows: 'The first Prejudice is that if a Tenant be at never so great paines or cost for the improvement of his Land, he doth thereby but occasion a greater Rack upon himself, or else invests his Land-Lord into his cost and labour *gratis*, or at best lies at his Land-Lords mercy for requitall, which occasions a great neglect of all good Husbandry, to his own, the Land, the Land-Lord, and the Commonwealths suffering. Now this I humbly conceive may be removed if there were a law enacted, by which every Land-Lord should be obliged either to give him reasonable allowance for his clear improvements, or else suffer him or his to enjoy it so much longer as till he hath had a proportionable requitall. As in *Flanders* and elsewhere, in hiring leases upon improvement, if the Farmer improve it to such a rate above the present value, the Land-Lord gives either so many years purchase for it, or allows him a part of it, or confirms more time; of which the Tenant being secured, he would Act Ingenuity with violence as upon his own, and draw forth the Earth to yeeld her utmost fruitfullness, which once being wrought into perfection will easily be maintained and kept up at the height of fruitfullness, which will be the Commonwealths great advantage. Some Tenants have Advanced Land from Twenty to Forty pounds *per an.* and depending upon the Land-Lords have been wip't of all, and many Farmers by this uncertainty have been impoverished and left under great disgrace, which might as well have been advanced.'

Nothing came of this quaint and eloquent plea; and although later agricultural writers than Blith frequently lamented the hindrance to land improvement due to the lack of security for a tenant's outlay, and complained of the gross injustice commonly done to those who ventured to improve their farms without such security, no organized effort to obtain legislation on the subject occurred before the 19th century had well advanced. In the meantime tenant-right customs came into existence in some parts of England and Ireland, the most important of which was the Ulster Custom, which gave to the tenants of that province the rights of fixity of tenure, free sale, and fair rents under limitations imposed by estate rules. This Ulster Custom, by the way, was at once a survival and a development of ancient tenure generally developed in Ireland, and closely allied to the early copyhold system of England, but extinguished as a rule in other provinces by tyrannical encroachments by landlords, warfare, and penal laws. In Lincolnshire and a few other English counties, customs of granting compensation to quitting tenants for unexhausted improvements came into use during the first half of the past century. The earliest date at which the Lincolnshire Custom was mentioned by any witness before a Parliamentary Committee (to be referred to presently) as having been in operation was 'very soon after 1826', in reference to North Lincolnshire only, and the testimony of agricultural writers up to 1842 indicates that the custom had not become general in the county by that time.

The first Tenant Right Bill brought forward in Parliament was one for Ireland, introduced in the House of Commons by Mr. Sharman Crawford in 1835. Although it was rejected, it called attention to its subject. It was followed in 1841 by the first measure of the kind for England, introduced in the House of Lords by Lord Portman. It was a very short Bill, giving tenants a claim to compensation for unexhausted improvements made by them after giving notice to their landlords, unless the latter formally objected. It was discussed by the Peers, but did not come on for second reading in the year named. In 1843 it was again brought forward in a somewhat enlarged form, its consideration being again deferred. In 1844 it was read a second time in the House of Lords, and referred to a Select Committee, which, however, was not appointed, it having been decided that the subject should first be discussed in the other House. It was not till 1847, however, that Mr. Pusey, after consultation with Lord Portman and others, introduced a Bill backed by Mr. (afterwards Sir Thomas) Acland, giving to tenants an indefeasible right to compensation for their improvements, without detriment to the just interests of landlords. This measure was read a second time and referred to a Select

Committee, appointed in 1848, with Mr. Pusey as chairman, to take evidence upon the agricultural customs of England and Wales in relation to tenant right. A large number of witnesses from different counties were examined, and a great preponderance of the evidence was in favour, not only of legislation, but also of a compulsory law to secure to tenants the value of their improvements. Still, the Committee reported in favour of only permissive legislation, and Mr. Pusey's Bill was made permissive. In that useless form it was passed by the Commons, only to be rejected by the Lords; but the passing of a measure known as the Emblements Act, giving to tenants the right of removing buildings and fixtures erected with the consent of their landlords, has been attributed to the influence of Mr. Pusey's Committee. More important was the arousing of public interest in the subject, which thereafter became a topic for discussion by farmers' associations and in the Press.

In 1850 the Irish Tenant League was established, with the object of legalizing the Ulster Custom and extending it all over Ireland. But no argument or agitations on this subject affected the legislators of that time, as is shown by the actually retrograde character of the Landlord and Tenant (Ireland) Act of 1860, which, for one thing, made contract supreme, and attempted to annul considerations of tenure, although the report of the Devon Commission of 1844 had insisted upon the need of justly defining and regulating the respective claims of landlord and tenants to property in the soil. The Act was inoperative, except so far as it repealed certain barbarous laws of the past.

In 1870 was passed the Irish Land Act of that date, which led the way to a complete revolution in the land tenure of Ireland. It legalized the Ulster Custom and any similar custom proved to be in existence outside Ulster, and provided for compensation for disturbance of tenancy and tenants' improvements, as well as for the purchase by tenants of their holdings, while otherwise mitigating some of the abuses of the land system in Ireland. But it was faulty and defective in many respects, and the need of further legislation soon became apparent.

In consequence of the eviction from their farms, under circumstances of great injustice, of Mr. George Hope of Fenton Barns and Mr. Saddler of Ferrygate, Mr. James Howard, in 1872, gave notice of calling the attention of the House of Commons to the insecurity of tenant-farmers' capital and the public disadvantage thereby occasioned. As the press of public business prevented Mr. Howard from bringing forward his motion, he took the advice of Mr. C. S. Read, and gave notice that he would introduce a Bill to amend the Law of Landlord and Tenant in England. In conjunction with Mr. Read he prepared the Landlord and Tenant Bill which he introduced in 1873. It was an excellent measure, compulsory in principle, and it secured the support of some important agricultural associations, as well as a great many Members of Parliament. But Mr. Howard was ill when the date for its second reading arrived, and the Bill was dropped. If he and Mr. Read had agreed to omit the compulsory clause from it, there would not have been any difficulty in getting it through the House of Commons; but to this they unhesitatingly refused to consent. That they were right was proved when the Duke of Richmond's permissive Agricultural Holdings Bill of 1875, 'a homily to landlords' as it was properly called, had become law, as evidence showed that it was almost entirely inoperative.

The Farmers' Alliance, founded in 1879, gave a great impetus to the tenant-right agitation, and published the draft of a Land Bill of a more advanced character than any measure yet passed for England or Scotland, though some of its provisions have since been embodied in Acts of Parliament. It provided for free sale of improvements, with a sufficiency of fixity of tenure to prevent the confiscation of purchased improvements by means of an advanced rent, and gave freedom of cultivation and sale of produce, besides arranging for the payment of tithe compulsorily by landlords, and the division of rates between landlord and tenant in England, as in force in Scotland.

In 1881 the Land Law (Ireland) Act was passed, securing to tenants fixity of tenure, free sale, and rents valued by a land court, and extending the provisions of the Act of 1870 for enabling tenants to purchase their holdings. This measure resulted in a great reduction of rents; but in some respects its operation was marred by complications and compromising provisions. Further legislation, apart from the Arrears of Rent Act of 1882 and the Redemption of Rent Act of 1891, was mainly in the direction of land purchase, provided for in the Acts of 1885, 1887, 1888, 1889, 1891, 1896, 1901, and 1903. Under this legislation a tenant is enabled to acquire the fee simple of his holding by payment of an annual sum less than his rent for a specified number of years.

It was not till eight years after the abortive Agricultural Holdings (England) Act had passed that the semi-compulsory Act of 1883 was brought forward. It was only semi-compulsory, because agreements providing for 'fair and reasonable compensation' were allowed to be substituted for compensation under the Act. As the measure was framed, this alternative proved advantageous, for numbers of tenants were able to make terms with their landlords more satisfactory than the results of the settlement of claims and counterclaims by arbitrators. Moreover, apart from draining, for which only notice was required, it was only temporary improvements which could be carried out without the landlord's consent. The Act mitigated the harshness of the Law of Distress, and improved tenants' rights as to fixtures. But it did nothing towards securing freedom of cultivation and sale of produce. Besides, like all tenant-right measures for Great Britain carried up to the present time, the Act provided for compensation for improvements only by means of arbitration, which will never give satisfactory results. In the great majority of cases tried under this and subsequent Acts the tenant has put in a claim, and his landlord a counterclaim,

and the arbitration has resulted in the allowance of a portion of each, with small advantage to either party after the payment of expenses.

In 1890 a short Act was passed to prevent gross injustice perpetrated in a few instances by mortgagees taking possession of farms, and repudiating the landlords' liabilities for improvements. A special Act to protect the improvements of market gardeners was carried in 1895. A great part of its intended benefit was annulled by a legal judgment; but this was rectified by a short amending Act.

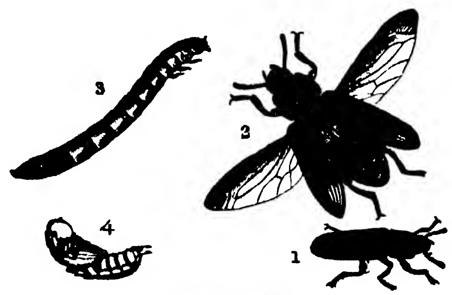
The great merit of the Agricultural Holdings Act of 1900 was the abolition of penal rents for breaches or non-fulfilment of covenants, excepting those relating to breaking-up permanent pasture, grubbing underwoods, felling, cutting, lopping, or injuring trees, or regulating the burning of heather. These exceptions, which ought equally with other breaches of covenants to have been left to be settled by arbitration, detracted from the benefit of the Act. This measure, like the Act of 1883, contained the absurd stipulation that in estimating the value of a tenant's improvements, no account should be taken of 'what is justly due to the inherent capabilities of the soil'. These capabilities are precisely what the tenant pays for in rent, and it is their development which constitutes his improvements, so far as the soil is concerned. The proviso, however, has not affected allowances for improvements, simply because these have always been based upon expenditure, instead of upon the declared principle of the Acts, which is value to an incoming tenant.

The Agricultural Holdings Act of 1906 is notable for giving to the tenant a claim to damage done to his crops by game which he has not a right to kill, for definitely securing to him freedom of cropping and sale of produce, for providing for compensation for unreasonable disturbance, for dispensing with the landlord's consent to the execution of certain permanent improvements, and for giving a right to landlord or tenant to insist at the commencement of a tenancy upon a record of the condition of the farm and all that is upon it and its state of cultivation. This record would be a means of facilitating claims for accumulated fertility, now generally disallowed by arbitrators.

The whole of the Agricultural Holdings Acts and the Market Gardeners Acts for England and Scotland respectively were consolidated in Acts passed in 1908. In spite of the amendments of the earlier Acts embodied in the more recent measures, they cannot be regarded as settling the tenant-right question. Nothing short of the right of a tenant to sell his tenancy in the open market, with pre-emption to the landlord, will do that. Such a right would need to be safeguarded by provisions as to reasonable permanence of tenure and the prevention of the confiscation of the purchase price in a rise of rent. This is objected to as 'dual ownership'; but where the properties of two persons are inextricably mixed in the soil, there must be dual ownership or confiscation. Such abuses of the system as have prevailed in Ireland could be prevented by well-considered provisions. The system, which has worked well in the Evesham district under voluntary arrangements, is the only one which allows perfect liberty to the tenant to improve his farm to the utmost profitable extent without injustice or hardship to his landlord. The former, as he should, would take all risks of the results of his enterprise being unprofitable, and he would then be entitled to the full advantages of successful ventures. See also arts. LAND, LAND TENURE, IRISH LAND ACTS, and AGRICULTURAL HOLDINGS ACTS. [W. E. B.]

Tendons, Diseases of and Injuries to.—The diseases of tendons are chiefly those caused by overstrain or extension, tendons being in themselves inelastic, and any undue elongation by force resulting in the rupture of some of their fibres. Their attachments to bone may be torn away, and themselves put out of action by having no hold. Friction and injury to tendons occurs from adventitious growths, as when splints form in a backward direction upon the cannon bones and present rough surfaces against which they must come in contact in their natural play. They become infiltrated by inflammation occurring in the tissues surrounding them, and undergo some degree of softening, but on the whole are remarkably resistant to communicated disease, unless it takes the character of inflammation of a joint or ossific deposits. When chronic navicular disease exists, the insertion of the tendon into the bone is often found degenerate. Thorns and other sharp bodies enter the substance of a tendon and cause swelling and inflammation, and it is often difficult to find them. Contraction of the tendons is the cause of bent front legs, and inability to place the heels of hind feet upon the ground. An operation known as tenotomy, by which tendons are divided, is sometimes performed; but having regard to the long time occupied in repair and the indifferent material substituted, it is of doubtful value, and the difficulty is commonly met by special shoes which enable the animal to work for a length of time without pain, and perhaps without further contraction (see TENOTOMY). [H. L.]

Tenebrio molitor, Linn. (the Meal-worm Beetle), generates in flour, bran, and meal-bins,



Tenebrio molitor

1, Adult beetle (natural size); 2, beetle flying (magnified); 3, larva; 4, pupa.

and is consequently found in granaries, mills, and farmhouses. The beetles appear in April,

May, and June. They are smooth, slightly depressed, and of a pitchy or chestnut colour; head somewhat orbicular, with two small eyes, and short, slender, eleven-jointed antennæ; elytra elliptical, with sixteen shallow furrows, and beneath them ample wings, which are smoky on the costa; legs stout; tarsus five-jointed, hinder pair with only four joints. The meal-worm is cylindrical, smooth, ochreous, with bright, rusty bands, and a few scattered hairs; two small horns, six pectoral legs, and two minute spines at the tail. It much resembles a large and rather flat wireworm. The pupa is pale-ochreous, with the members visible, and two spines at the tail. Cleanliness is the best preventive. The meal-worm is a favourite food of nightingales. [J. C.] [C. W.]

Tenebroides mauritanica (the Cadelle).—This imported insect is sometimes found in granaries and malt-houses in England, but it requires a more southern climate to render it abundant. The larvæ feed on stored corn, bread, almonds, rotten floors, and dead trees. They live in this state a year and a half, and when full-grown are sometimes nearly ¾ in. long. They are flattened, fleshy, rough, with scattered hairs, and whitish, tapering towards the head, formed of twelve distinct segments besides the head, which is horny and black; the tail is horny, with two hooks. They pupate in the earth or amongst any refuse at hand; and the beetle which hatches from them is the *T. mauritanicus* of Linnæus, and the *T. caraboides* of Fabricius. It is depressed, shining, and of a pitchy or deep-chestnut colour, and regularly punctured; the head is large, with strong jaws, two small eyes, and two short clubbed antennæ; elytra large, elliptical, with eighteen delicately punctured lines. The tarsi are four-jointed. The beetles are longlived, and are said to be carnivorous, destroying the corn moths, &c. [J. C.] [C. W.]

Tenotomy.—The division of a tendon, as a remedy for the deformity resulting from its contraction, is called tenotomy, and is practised in cases where the heel cannot be put to the ground. It has been tried as a remedy for stringhalt, but with no great advantage. New tendon does not fill the space between the divided ends, and the fibrous substitute is lacking in strength. Nevertheless there are cases where division of the *perforans* and *perforatus* tendons have restored the subjects of deformity and lameness to prolonged usefulness in labour not requiring fast paces. See TENDONS, DISEASES OF. [H. L.]

Tent Caterpillars, a general name applied to those larvæ which form on trees tent-like nests of silk beneath which they shelter. By far the commonest and most destructive is the Lackey Moth Caterpillar (*Clisiocampa neustria*), though in some districts the larvæ of the Brown-tail Moth (*Porthesia chrysorrhœa*) does considerable damage. Various species of Hyponomeuta larvæ also spin tents. See CLISIOCAMPA, PORTHESIA, and HYPONOMEUTA. [R. H. L.]

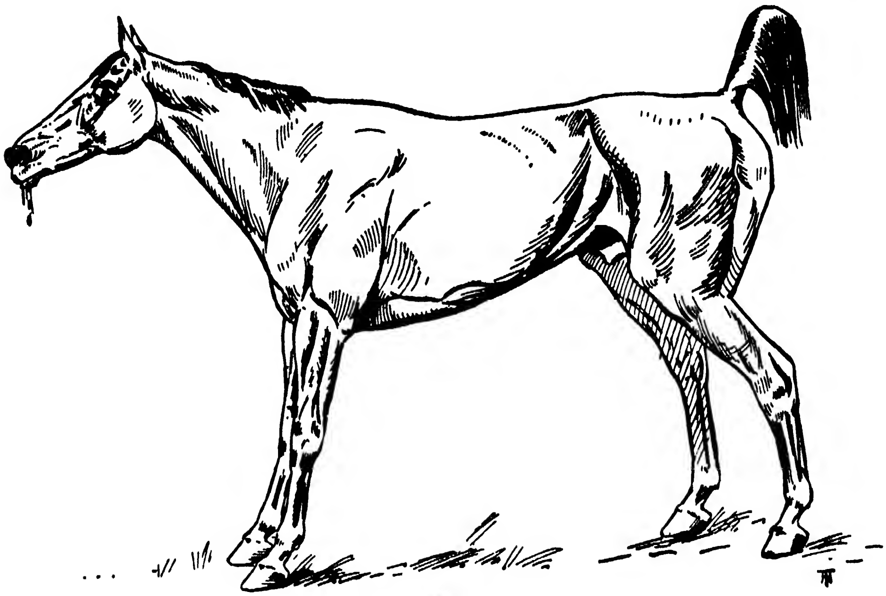
Tenthredinidæ, a family of the Hymenoptera including most of the insects popularly known as sawflies. The four wings are not unlike those of a bee, but the body lacks the 'waist' or peduncle which gives mobility to the abdomen of the stinging Hymenoptera, and the thorax is attached broadly to the abdomen. The female is furnished with a characteristic apparatus in the place of a sting. It consists of a pair of saws with their cutting edges on the outer side, and by means of it slits are cut in leaves or stems for the insertion of eggs. The grubs or larvæ of the Tenthredinidæ are easily distinguishable on careful observation. They bear a general resemblance to the caterpillars of butterflies and moths, and indeed are sometimes known as 'false caterpillars'; but while the larvæ of both groups, in addition to six true legs, have a number of 'pro-legs' or suckers, these suckers are never more than ten in the Lepidoptera, and never fewer than twelve in the Tenthredinidæ. A few of these sawfly grubs live within galls, in which case the legs are much reduced in size, but most are leaf-feeders, and among them are many of the more serious enemies of plant life. The Pine Sawfly (see LOPHYRUS), the Apple Sawfly (see HOPLOCAMPA), and the Gooseberry Sawfly (see NEMATUS) may be mentioned. In dealing with the pest the particular life-history in each case must be considered, but usually the winter is passed in the chrysalis state in the soil under the infested plants, and if the surface soil be removed and buried deeply, or treated in such a way as shall kill the hibernating insects, the attack will not be renewed in the following year. [C. W.]

Terms, Removal. See REMOVAL TERMS and QUARTER DAYS.

Terrier. See arts. SCOTCH TERRIER, IRISH TERRIER, SKYE TERRIER, TOY TERRIER, AIREDALE TERRIER, WELSH TERRIER.

Tetanus, called 'lockjaw' from a frequent symptom consisting in inability to properly open the mouth, is an infective disease caused by a specific bacillus (*B. tetani*) whose resistance to ordinary disinfectants is very great, particularly in the spore form. It has been demonstrated that a 5-per-cent carbolic solution had no effect upon the spores when the latter were subjected to its influence for ten hours. Castrators' clams may retain the virus for eighteen months although boiled for five minutes (Nocard). All the recognized disinfectants destroy the bacillus if given sufficient time, but must be chosen according to the situation to be acted upon. The organism is found in many soils, and in greater proportion in tropical climates, and its common mode of entry into the body is by some wound or abrasion, often very minute, and so difficult to discover that for many years a variety of tetanus was believed to arise idiopathically, a view now discarded. The symptoms of tetanus are not produced by a dissemination of the bacilli throughout the living animal, but a general intoxication is caused by the products of a stationary vegetation, as for instance in the case of a broken knee. If the wound is explored, the bacilli will be found abundant in its lower layers only, and none will be present in blood drawn from the jugular vein. This knowledge is turned to account in the treatment when tetanus supervenes on

wounds and the surgeon seeks to destroy the enemy by removing the cause. The effect ceases if the patient has not already taken up a lethal quantity of the excretory products of the tetanus bacillus. Pricked or punctured wounds about the feet offer greater facilities than others for the entrance of these malignant organisms. They are not necessarily more susceptible, although, centuries before the true cause was known, tetanus was observed to follow them more frequently than others All domestic mammals are liable to the disease. Horses, asses, and mules most so; then sheep and goats, and dogs least. The period of incubation varies from six hours to eight weeks, but inoculation shows that in horses four or five days, and in sheep two to four days, is the usual time; which accords with the common experience that if the ninth day is passed safely there is very little risk of tetanus supervening. The same may be said of it when following on parturition in cows, these animals contracting it through abrasions incurred in difficult labours where forcible extraction has been found necessary. The symptoms are not always pronounced at first, and horses are sometimes found at work without the man's cognizance of anything being amiss. A shaking of the tail or carrying it to one side may be the precursor of violent tetanic spasms of the more important muscles of the haunch. More generally the muscles of the neck are first affected, then the throat, trunk, and extremities. The

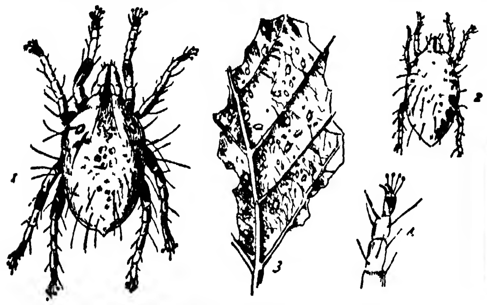


Tetanus

outstretched head and difficulty of mastication is followed by retraction of the eyeball and protrusion of the haw, which is so peculiar to this disease. A high state of nervous excitement, and spasm amounting to a fit, is witnessed in some cases; and the rattle of a bucket or chain, the slamming of a door or other sound, may accelerate a tetanic spasm in a patient which up to that time has been standing almost still. It is generally fatal. It has been observed that bulls castrated by the seemingly scientific and cleanly method of ligaturing, more frequently develop tetanus than those subjected to the rougher methods of the unqualified practitioner. Lambs are more susceptible to tetanus after castration than other species in this country.

Treatment.—Constitutional remedies of the direct sedative class are given to allay the excitement, but without much result, as its continuance depends upon the amount of tetanic products already in the circulation. Perfect repose and freedom from excitement may enable the animal to outlive the attack, provided the 'dose' has not been too large. An anti-tetanin serum has been employed with some small measure of success where the malady was feared and anticipatory treatment adopted, but it is of extremely doubtful value when once the disease has declared itself. Our most hopeful means of combating it is to delve to the bottom of the wound (if one can be found) and destroy the germs with solutions of perchloride of mercury, of creolin, carbolic acid, or permanganate. After parturition, castration, pricked foot, or broken knees, we have no need to seek the enemy's camp, but must make a choice of remedies. For vaginal membranes, a 2- or 3-per-cent permanganate solution; for castration wound, a 5-per-cent or even stronger carbolic dressing; and for feet and knees and distant injuries without communication with the abdominal cavity, we may prefer a 1-per-cent perchloride of mercury preparation. Soft foods, easily sucked up and swallowed without effort at mastication, should be provided, and a considerable time allowed for perfect restoration. [H. L.]

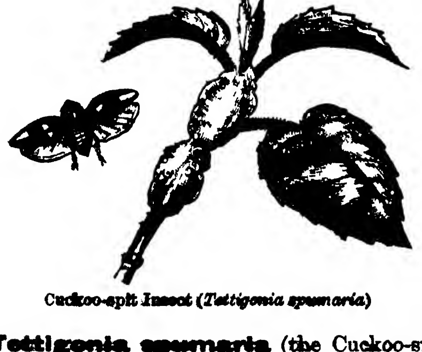
Tetranychus, a genus of spinning mites, popularly known as 'red spider', and frequently highly injurious in greenhouses, hop gardens, and orchards. The larger gooseberry red spider is of a different genus (see BRYOBIA). The Tetranychus mites are very minute, seldom exceeding $\frac{1}{50}$ in. in length. They infest the under sides of the leaves, covering them with extremely fine silken threads which afford a protection to



Red Spider (*Tetranychus telarius*)
1, Adult; 2, larva; 3, leaf with mites and eggs; 4, foot (mag.).

the mites and their eggs. They live on the juices of the leaves, and produce in them a characteristic scorched appearance, which is sometimes indicated by the popular name of the disease (fireblast, kupferbrand, &c.). There is some confusion as to the species, and in most cases the mite is indiscriminately alluded to as *T. telarius*, the spinning mite so conspicuous for the dense web it often makes on furze bushes, though some consider the hop red spider to be a different species, *T. altheæ*.

The disease is always most severe in prolonged dry weather. Under glass it can be effectively treated by tobacco fumigation; but in the open, direct insecticide washes must be used, applied with force to the under surface of the leaves, and repeated at intervals, for the eggs, always hard to kill, are doubly protected by their tough shells and the silk webbing spun by the mites. Ordinary paraffin washes should be reinforced by the addition of liver of sulphur, which seems to have a specific action upon mites, and a wash should be repeated after an interval of three days. [C. W.]


Cuckoo-spit Insect (*Tettigonia spumaria*)

Tettigonia spumaria (the Cuckoo-spit insect) is a familiar garden pest, often causing serious injury to roses, Michaelmas daisies, &c. It is a member of the group of bugs (Hemiptera) known scientifically as Cercopidæ, and popularly as Frog-flies or Frog-hoppers. The froth is exuded by the young insect and serves to conceal and protect it, while it extracts the juices from the tender new shoots by means of a long proboscis which pierces the tissues. The adult insect is about $\frac{1}{4}$ in. in length, greyish-yellow in colour, and a very active jumper. Paraffin emulsion is fairly effective against this pest, but better results are obtained from the use of a tobacco wash, $\frac{1}{2}$ lb. of tobacco sufficing for 12 gal. of water. A pound of soft soap should be added to the wash. [C. W.]

Texas Fever, a cattle disease found in an acute form in summer and a chronic form in autumn; in many respects it resembles red-water. By the more recent experimenters it is said to be identical, and the cause to be a protozoon (piroplasm) conveyed by ticks. The piroplasms are pear-shaped bodies found in the interior of the red blood corpuscles. The bite of the infected tick carries into the beast the blood parasites, and these can be found in the blood of the sick animal by examination of a drop drawn from any part of the body and placed under the microscope. The symptoms commence with dullness and high temperature (from 105° to 107° F.), loss of appetite, falling off in the milk of cows, constipation alternated by purging, breathlessness, and rapid wasting. In very acute cases death may result in four or five days, but a fortnight or more is the usual time; or some improvement is noted and then a relapse, when the disease will last for months. Prevention is to be aimed at by several means. The ticks do not live upon the greasy skin of the sheep, and this affords us the opportunity of starving out the ticks by removing all cattle to a distance and grazing the pasture with other stock. About fifteen months is considered necessary for this purpose, for in that period the ticks and their progeny will have died. The nymphs are found to inherit the affection without themselves having sucked blood from an animal suffering from Texas fever; hence the importance of the full time allowance. Land worth cropping can be brought under treatment by the plough, but much of the infected areas consist of prairie, and only the above alternative of grazing immune stock is practicable. Cattle which have acquired immunity themselves may be covered with ticks and introduce the disease into districts previously free; and to prevent this, dipping has been largely adopted in America, the substances used being coal-tar compounds, fish oil, cotton-seed or other cheap oils. A bath consisting of 94 lb. of sulphur mixed with 875 gal. of petroleum is specially recommended. Protective inoculation produces a mild form of the malady and confers a variable degree of immunity. [H. L.]

Thatch, a term applied to straw or other material used to cover the roofs of buildings or hay and grain stacks to keep out the rain. The materials used for thatching vary considerably in different districts. Wheat and rye straw, when well laid, provide a neat and secure covering for all general purposes. The former is used chiefly for rick thatching, while the latter

is, when easily procurable, mostly used for the roofing of houses. Oat and barley straw are sometimes used, but they are generally somewhat soft in texture and absorb water, which gradually finds its way through the thatch. Thatch is often used as a protective covering for potatoes, mangels, and other roots which are placed in clamps; but when used for this purpose straw thatch cannot resist frost or conserve heat, it is only capable of preventing damage from rain.

There is no form of thatch to equal reeds (*Arundo phragmites*), which grow abundantly in shallow waters and ditches throughout all parts of Europe. A reed roof which has been well laid will last for fifty years without requiring repair, while well-drawn wheat straw properly laid will remain secure for thirty years. A 'hundred' of reed may cost as much as £3, 10*s.* and cover 5 'squares' of roof, the cost of laying usually amounting to 5*s.* per square. To this expenditure must be added the cost of tar twine for tying the reeds to the rafters, usually about 1*s.* 6*d.* Thus a covering of new reeds will cost as much as £1 for each hundred square feet, to which must be added the expense of roofing or placing a cap along the ridge, which, if well made, will cost as much as 1*s.* 6*d.* per foot run.

Heather or ling (*Calluna vulgaris*) is still largely used for thatching ornamental buildings such as rustic arbours, summer houses, &c. Such roofs have been known to last for more than a hundred years. They are considerably more weighty than straw thatch roofs, and where large areas have to be covered the roofs should either be made sufficiently strong, or allowed to pitch so as to throw the greater part of the weight on the walls.

In recent years many substitutes have been introduced to take the place of thatching, for example the erection of Dutch barns; but these can never entirely supersede the thatched ricks, although they are of undoubted value in rainy districts and seasons. Thus in the southern counties of England farmers are compelled to build their ricks in the fields where the corn or hay is grown. Waterproof cloths or metal caps fitting closely over ricks have not yet proved entirely satisfactory, for, unlike thatch, they do not permit the heat and moisture from the rick to escape freely. The latter are among the principal advantages of straw thatch.

[J. C. N.]

Thatching is an operation requiring considerable care, observation, and practice before it can be successfully accomplished. A thatcher's outfit is neither expensive nor elaborate. It consists usually of a billhook, a paring knife, or sheep-shears for trimming the eaves, a large-forked stick to contain the drawn straw or 'yealms', and a wooden hand-rake with iron teeth for combing the straw when laid on the rick, together with a supply of cord or oakum, and maybe a wooden mallet for driving in long wooden pegs or spars to which the cord is secured. The preparation of the straw is of chief importance, as if used in a dry irregular mass it would be ineffective in running off rainwater;

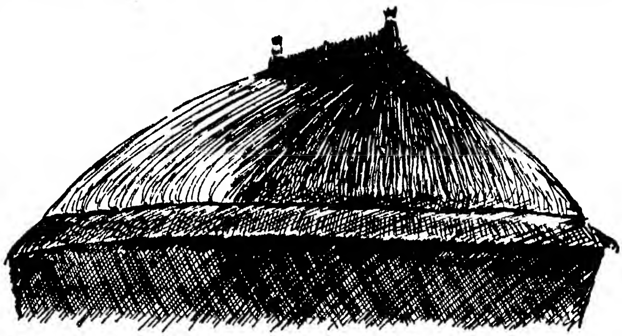


Fig 1.– General Appearance of Thatched Hay Rick

therefore, in order to secure the best results, the straw is well moistened with water, after which the heap is turned with a fork, and finally compressed by beating or lightly treading; this has the effect of ridding the straw of flag and shack. The straw is now 'yealmed' or drawn from the bottom of the heap, the usual method being to grasp as much straw as can be gripped in both hands. The straw is then drawn out by a rapid movement of the arms towards the right, followed by a swing over to the left, the yealms or drawn straw being laid at the worker's

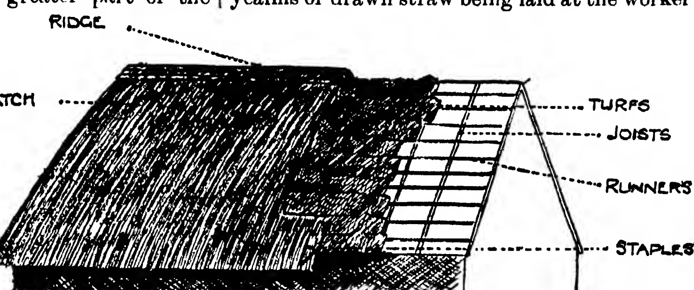


Fig 2.—Thatching Dwelling Houses—First Method

feet, the thickest end being at the right-hand side. The work of drawing the straw is usually undertaken by the thatcher's assistant or 'server'. When a given quantity of the partially straight straw has been collected, it is regulated by the fingers in order to remove any loose portion. The worker meanwhile draws the bundles towards his feet, until he has secured as much as he can hold in the grip of both hands. A yealm thus formed is never broken, but kept firm and secure until placed on the stack. Before thatch-

ing, the stack must be prepared by filling up any loose hollows with loose straw, and levelling any humps so that the roof may present a firm even surface. Usually the apex of the roof will require 'bolstering up' with a tightly tied bundle of straw. The thatcher commences by laying the straw at the bottom or eaves, packing it firmly and securely, and in regular breadths, until he reaches the top, when the straw is laid well up to form a point. This gives a good pitch for the water to run off. A medium thickness of straw well laid will resist water much better than a large quantity loosely packed together. In thatching hipped-end stacks it is customary to commence about the centre of one side so as to ensure a good finish; while gable-end stacks are generally commenced at one end.

To keep the thatch in position, pegs made of split hazel, willows, or other tough wood are used. These are usually cut into lengths of

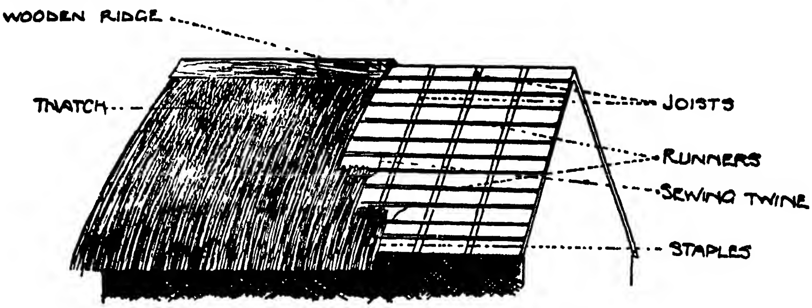


Fig 3 —Thatching Dwelling Houses—Second Method

from 2 to 3 ft., the ends being pointed and jagged. In the south of England, split hazel rods frequently take the place of cord between the pegs; while in other parts of the country, oakum or straw ropes are used. The final operation consists of trimming the eaves and ridge. [J. C. N.]

In Scotland the chief materials used for thatching are wheat straw, oat straw, and rushes, the last named being in especial favour in thatching hay stacks. Various methods are employed in preparing the straw, but in every case it must be arranged as nearly as possible after the manner of a newly cut sheaf, and the longer it is the better. In some districts the straw is made up into small bunches called 'staples', and tied securely together at one end with a few straws, while in others the straight-drawn straw is used without 'stapling'. The advantage of the former method is that the staples can be used several times for thatching straw stacks, or even the hay stacks of the following season, after they are taken off the corn stacks. Great care is necessary in putting on the thatch. A thin, evenly distributed layer rather than a thick, patchy covering is wanted, for its effectiveness as a rainproof covering depends upon the strength of its weakest parts. The work is best done when the stacks are dry and on a calm day. When the stack-heads are wet they lose their elasticity, and it is then much more difficult for the thatcher to put on the straw uniformly. Commencing at the eaves, the worker makes a beginning with a ring of staples, and in the case of corn stacks he allows them to project well over, so that the water may be effectively prevented from running down the sides of the stack. The heads of the staples are inserted in the stack-head securely enough to hold them firmly until the ropes are put on. A second ring of staples is then started a little higher up and made to carefully overlap the first; and so on until the crown is reached, where the heads of the highest staples converge. The adjacent staples must also carefully overlap one another so that a perfectly uniform covering may be obtained. After each course is laid on, and before shifting the ladder for the next course, the thatcher smooths it down with his thatching-stick and removes any loose straws. In the case of round stacks and at the 'hips' of rectangular stacks, there is a tendency to lay on the straw much more thinly at the eaves than near the crown, and the worker must guard against this. The crown of the stack is now finished off by placing on it some short straw for padding, and then some long, straight straw which overlaps the uppermost ring of staples. The next operation is to get the thatch secured by means of ropes, which may be made of straw

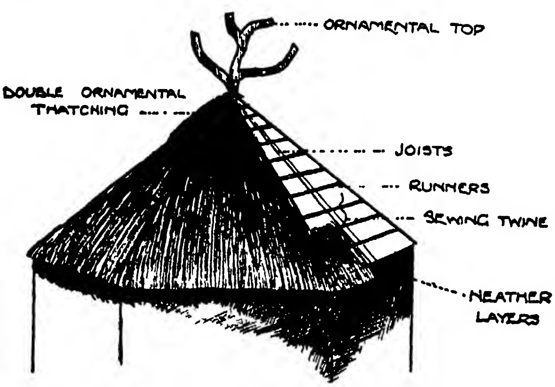


Fig 4 —Thatching Summer House

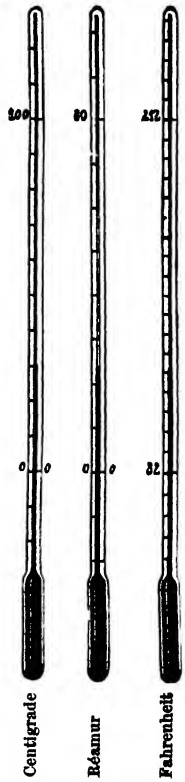
at the homestead or purchased, the latter serving for several years. A certain number are put over in the vertical direction, and to these the rest are attached. In the case of rectangular stacks the latter are usually fixed on horizontally at about 9 in. or 1 ft. apart; while for circular stacks they are either put on spirally from the crown to the eaves, or passed obliquely over the stack-head and fixed to a rope passed round immediately below the eaves. The overhanging ring of staples is now trimmed so that the eaves are quite horizontal and present a good finish and appearance. Where rushes are used for thatching, they are put on without stapling. The work is much more laborious and takes much longer time, but when accomplished it is extremely satisfactory. [J. W.]

Thatch-making Machines are used to make runs of straw thatch suitable to be laid on corn stacks in the place of ordinary thatching. They straighten the straw and yealm it to the required thickness, and then thread and tie it continuously with string, so as to make it shoot water when it is laid on an incline. Long runs of this, sufficient to reach from end to end of a roof, are made, and then rolled ready to be taken on to the stack. [W. J. M.]

Theobaldinella annulata is a large gnat or mosquito, plentiful in the south of England, and often the cause of considerable annoyance. It has spotted wings and banded legs, and its early stages, as is the case with all mosquitoes, are passed in stagnant water, especially rainwater barrels and cisterns. The trouble from mosquitoes may be greatly mitigated if such reservoirs of rainwater are covered with lids of perforated zinc, or they may be treated with a small quantity of paraffin oil. This floats on the surface and is fatal to the mosquito grubs, which cannot breathe beneath the water, and are thus deprived of their air supply. [C. W.]

Thermometers.—The thermometers in ordinary use are closed glass tubes blown out to a bulb at one end and containing mercury which expands or contracts as the temperature rises or falls, the space above the mercury forming a vacuum. The point at which the mercury stands when the thermometer is immersed in powdered ice is marked as 0° C. or 32° F. as the case may be, and the temperature of steam coming from water boiling under the normal pressure of the atmosphere is marked 100° C. or 212° F. (see TEMPERATURE). The tube of the thermometer being supposed to be of uniform bore, the length between these two points is divided into 100 parts (Centigrade) or 180 (Fahrenheit); or, to speak more accurately, the volume of the tube is equally sub-divided, and the graduations are inserted accordingly. It will thus be seen that the scale of a thermometer depends upon the properties of mercury, say on the regularity with which mercury expands and contracts as its temperature varies. In graduating above the boiling-point of water and below the melting-point of ice, the expansion and contraction of mercury are also used; that is to say, the mark for 110° C., for instance, is placed as far above the 100° C. mark as 90° C. is below it. Réamur's thermometer, in use in Germany, has the space between the freezing and boiling points divided into 80 equal parts, the zero being at freezing.

Mercurial thermometers serve for nearly all the purposes of ordinary life, but in extreme cold mercury solidifies, and therefore alcohol is used to fill thermometers intended to measure very low temperatures. Alcohol thermometers are graduated to correspond with mercurial thermometers degree for degree. For scientific purposes thermometers are in use containing hydrogen gas or air, and the degrees which depend on the expansion of gases are taken as standards, with which the degrees of mercurial thermometers have to be compared in problems involving the principles of thermodynamics.



Thermometer Scales

For practical purposes a thermometer should have the bore of the tube small in comparison with the capacity of the bulb, so that the degrees may be far enough apart to read clearly; on the other hand, the bulb must be small in order that the thermometer may be rapidly brought to the temperature it is desired to measure. The scale should be etched on the glass itself. The marks are sometimes difficult to read; but if they are rubbed first with some stiff grease and then with a little powdered charcoal or rouge, and then wiped, the marks will be made clear and easy to see.

Various minor modifications are made in thermometers for special purposes. Clinical thermometers, for example, are graduated for a short length only, and the normal temperature for man and the principal domestic animals is indicated. Maximum and minimum thermometers are provided with index markers that show the highest and lowest temperatures respectively to which they have been subjected since they were previously set. [C. M. L.]

Thinning Green Crops. See art. SINGLING.

Thirlage is in Scots law a restriction on lands and their occupiers whereby they are astricted or thirled to a particular mill for the grinding of grain under burden of paying such rates and services as are expressed or implied in the constitution of the right. In 1799 statutory provision was made for the commutation of thirlage, and since then this restriction has, by agreement or otherwise, practically become obsolete.

Thirlage was constituted usually by deed, but might also be constituted by prescription or implication. When constituted, the occupiers of the lands thirled were taken bound, on the erection of the mill, to bring their grain to it to be ground, and were prohibited from having it ground elsewhere, even the use of querns or hand mills being prohibited. The area thirled to the mill was known as the thirl or sucken, while the parties liable were called the suckeners. Thirlage was of three degrees, viz.:—

1. Of all the grain raised on the lands, whether actually ground, or sold unground to dealers, or malted. But horse and seed corn, and corn paid as rent or feu duty, if delivered unground, was excepted.

2. Of all grindable corn, *i.e.* all corn actually ground or which required to be ground for the use of the suckener and his family. Any surplus beyond this might, in this case, be sold off the sucken without liability.

3. Of all corn brought into the thirl, whether grown on the lands or not, and ground there, or that 'tholes fire and water', *i.e.* undergoes any operation which the mill was fitted to perform, but this does not include baking or brewing.

The right of thirlage does not give the owner of the mill, as such, any right to interfere with the occupier's mode of cultivating his lands, and consequently the obligation might be evaded by laying the lands down to pasture.

Payment was usually made in kind, and the quantity of grain payable to the mill-owner was known as multures. Insucken multures were those paid by the suckeners, while outsucken multures were those paid by persons not astricted who voluntarily resorted to the mill for the grinding of their corn. Insucken multures were higher, since they represented the 'monopoly price of grinding', while outsucken multures would, of course, be based on current rates for the work done. Dry multures were fixed duties paid annually whether the grain was ground or not, as a condition of freedom from the burden. In addition, the suckeners were liable in certain payments in kind to the servants of the mill known as 'sequels', and variously designated as knaveship, bannock, and lock or gowpen. Moreover, the suckeners were under obligation to render certain personal services, such as furnishing thatch and carrying millstones and material necessary for the repair of the mill, cleaning and repairing the mill dam and lade, &c.

If the occupier tried to evade the obligation, it was at one time competent to seize the grain, but for long the mill-owner's remedy has been by action of abstracted multures, whereby the offending suckener is mulcted in damages which are usually computed at double the insucken multures. If, however, the mill was insufficient, the obligations of the suckeners were suspended till the mill was again in a condition to do the work, provided they gave the notice and waited forty-eight hours without having the work done. The right can be extinguished by written discharge, or may be lost by disuse for the prescriptive period. It may also be extinguished if the mill becomes ruinous or is destroyed; but the right will revive if a new mill is erected, within the limits of the thirl, before the expiry of forty years. The right may also be extinguished by commutation in virtue of the provisions of 39 Geo. III, c. 55, whereby it is enacted that the sheriff on application may commute the burden into an annual payment as fixed by a jury of heritors or tenants who occupy land of an annual rental of £30.

It appears that astriction to the smithy of a barony was at one time recognized in Scotland, and was said to be common in the northern counties as late as the middle of the 18th century. [D. B.]

Thistle is the common name for a genus of composite plants with hard stems, spiny leaves, and heads of tubular flowers, each head protected by a spiny involucre of specially modified leaves. The species luxuriate on rich land, and are considered the worst of all weeds, infesting not only the grass, but the corn crops of arable land. Certain species, such as Spear and Marsh Thistles, are specially troublesome, since the stems bear spiny wings which descend from the leaves, and thus the whole air part of the plant, stem as well as leaves, is prickly. All these thistle weeds reproduce in one way. Each fertile flower in the head produces a hard case protecting a single seed within. To facilitate distribution by the wind, each seedcase is crowned by a tuft of 'thistle down', composed of simple hairs in the true thistles, or of hairs branched like a feather in the plume thistles. Accordingly, to prevent the spread of thistles from field to field, seeding must be prevented. In the case of thistles which creep underground (Creeping Thistles) it is necessary also to get rid of the underground creeping parts.

The troublesome species of Thistle are—

A. *Biennial.*—1. Spear Thistle (*Cnicus lanceolatus*). 2. Marsh Thistle (*Cnicus palustris*). 3. Cotton Thistle (*Onopordon Acanthium*).

B. *Perennial Underground Creepers.*—4. Dwarf or Stemless Thistle (*Cnicus acaulis*). 5. Creeping Thistle (*Cnicus arvensis*).

1. SPEAR THISTLE affects all good soils, and is found in pastures, meadows, on roadsides, &c. It is a taprooted biennial which, in the first year of its life, produces a rosette of ground leaves with a central bud. During the second year the bud develops into a stout stem 3 or 4 ft. high, bearing spiny wings, large spiny leaves, and large flower-heads over 1 in. in diameter and 1½ in. long when in flower. Flowering occurs from July on to October. Later, 'seeds' are produced in abundance, and scattered freely, since each 'seed' bears a crown of feathery hairs which the wind readily catches. After seeding, the plant dies. To prevent spread, the plant should be cut in June and July. The seedlings with the rosette of leaves should be spudded out in autumn and early spring.

2. MARSH THISTLE is a biennial, 4 or 5 ft. high, frequenting damp pastures and meadows. Its habit of growth is like Spear Thistle, with a rosette of ground leaves and a spiny stem, but the flower-heads are small and in dense clusters. Marsh Thistle is eradicated by cutting, exactly as for Spear Thistle.

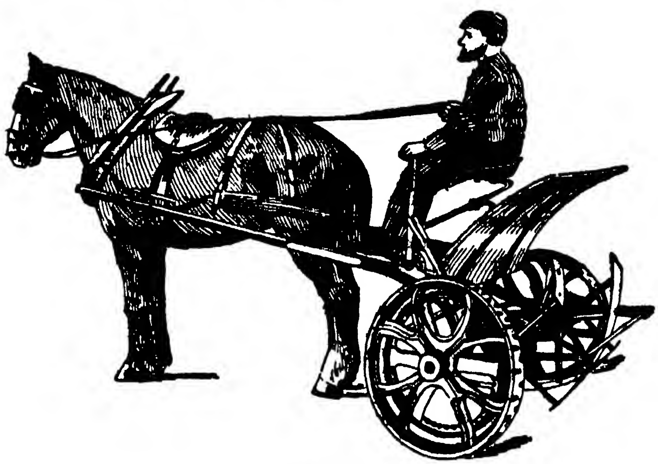
3. Cotton Thistle, or Scotch Thistle, frequents dry ground. It is a stout, branched, very prickly biennial covered with a loose cottony wool, and sometimes 6 ft. high. The flower-heads are large globes 1½ to 2 in. in diameter, containing pale-purple flowers. Flowering occurs from July to September. The plant is reproduced from 'seeds', which are crowned by simple, not feathery, hairs. This species is eradicated like the other biennial thistles.

4. Dwarf or Stemless Thistle grows in pastures on dry, calcareous, and gravelly soils, when it is often troublesome. Underground there is an extensive horizontal stem which confers perennial character and gives rise to the air shoots, each shoot composed of a rosette of spiny ground leaves, in the midst of which sit one or a few rather large egg-shaped flower-heads from which the crimson flowers protrude. Flowering occurs from July to September. This thistle is reproduced from 'seeds' provided with a crown of feathery hairs, and propagated by the underground stem. For eradication, the plant should be spudded out as soon as the flower-heads appear, and a pinch of sulphate of ammonia or of sulphate of copper (bluestone) applied to the cut surface.

5. Creeping Thistle is one of the most common and most troublesome pests of agriculture, infesting both arable and grass land. The power of this plant depends mainly on the possession of an extensive branched and deep-seated underground stem, not thicker than a small quill, which extends through the ground, confers perennial character, and propagates in all directions, sending up air shoots 3 to 4 ft. high. The stem of the air shoot is almost destitute of spiny wings, and towards the apex bears a flat-topped cluster of stalked flower-heads, each head from ½ to 1 in. in diameter. Flowering occurs from July to September. On some plants the heads are barren and never make seed, but on the others the heads bear 'seeds' which germinate and reproduce the plant. The 'seed' has a crown of feathery hairs, so that it is readily carried by the wind and sown at a distance.

For eradication in the corn crop, the hoe should be used freely early and late in spring; and when the corn gets up, as many plants as possible should be hand-pulled. In pastures, repeated systematic cutting continued throughout two seasons will exhaust the food supplies of the underground creeping stem and exterminate this pest. In root crops, the hoe should be kept constantly at work to prevent the new shoots from supplying food to the underground creeping stems. Two root crops in succession, systematically cleaned, suffice to destroy Field Thistle. Sow Thistles (see Sow Thistle) are readily distinguished from the true thistles above described by the milky juice and the succulent stem. See illustration under article Weeds. [A. N. M'A.]

Thistle Cutters generally take the form of a travelling frame geared to actuate a rotary drum which, instead of having heavy beaters, is fitted with sharp steel edges, which in rapid revolution cut off the thistles. The machines are designed to allow the cutting to be adjusted to requirements. It is rather doubtful if it is worth while to spend money on a special cutter, as the ordinary mowing machine is quite capable of cutting the thistles; and now through perfection of construction and easy control of levers to raise and lower the cutter bar, it is easy to regulate the cutting so as to cut the thistles and leave the grass uninjured. Thistle cutters have been made in which the cutting is effected by horizontal blades on radial metal arms attached to a vertical spindle made to revolve quickly. These will cut thistles, which after all is not a difficult matter, as a blunt-edge brought sharply against a thistle will do this; but in this form of cutter there seems special liability to trouble on rough ground where there are high ant heaps or other obstacles. [W. J. M.]



Thistle Cutter

Thomas Phosphate. See art. Basic Slag.

Thoroughbred Horses.—The term 'Thoroughbred' is used throughout the following pages as a matter of convenience, though the word is of comparatively recent coinage. In early days, the racer was termed a 'running horse' or 'plate horse'; in the latter part of the 17th and the earlier half of the 18th century, the term 'blood horse' came into use, to describe animals which owed their parentage to Eastern sire or mare. The word 'Thoroughbred' seems to have been coined during the first decade of the last century, occurring as it does in the Sporting Magazine of 1806; but not for many years after that date did it obtain general currency; as late as 1831 William Youatt (in his

book The Horse) thought it necessary to write of 'the Thoroughbred or Turf' horse.

History.—Eastern horses have been brought into this country from a very early period. Henry I (1100–35) received two Arabs as a gift; and we might trace such occasional importations from the East down to the Stewart period, when they became much more frequent. King James I (1603–25) acquired many Eastern horses by gift or purchase. On one occasion he received as a present twenty-seven 'Neapolitan coursers', of which eleven were stallions; this breed had a strong strain of Barb or Arab blood. In the year 1617 he received half a dozen Barbs, which were sent direct to the Royal stud at Newmarket. The Markham Arabian for which he paid £154 on 20th December, 1616, is the best-known of James I's importations, but this horse proved a failure at the stud. The Helmsley Turk imported in Charles I's reign (1625–45) is the first Eastern sire known to have made his mark upon our English breed. He became the sire of Bustler and Hutton's Royal Colt, whose names occur in the pedigree of Eclipse. 'His blood has been chiefly transmitted to our time through Old Merlin, Blunderbuss, the Bolton Starling, the Bolton Sweepstakes, and the Blacklegs mare' (Osborne). The Blacklegs mare was the dam of Marske, sire of Eclipse.

While we trace the descent of our Thoroughbreds from Eclipse, Herod, and Matchem, more especially to the first, there are, in the pedigrees of these three horses, blanks which cannot now be filled. The dams' names are far more frequently wanting than the sires; and in regard to this we must bear in mind that breeders in those days were careless in recording particulars of their stud work. This is not surprising; even at the present day, compilers of stud records find difficulty in obtaining accurate pedigrees. A contributing factor to the mistiness of the old pedigrees was the frequent omission to name horses and mares—an omission not uncommon within our own time, during which great races have been won by horses upon which their owners had bestowed no names.

Though stud books did not exist in the early days, breeders were well informed concerning the merits of horses on the turf. Richard Blome says: 'By having Plates run for at several times and in several counties we have come to know exactly the *speed*, *wind*, *force* and *heart* of every horse that runs, which directs us infallibly in our choice when we have to furnish ourselves for the *War*, *Hunting*, *Breeding*, the *Road* and the like' (Gentlemen's Recreation, 1686). This passage has important bearing on the present subject, as it shows that racehorses at this time were used to breed stock for all saddle purposes. Nevertheless there were studs maintained solely for racing before Blome's time.

King Charles had a large one at Tutbury in Staffordshire, which in July, 1649, numbered 139, all mares and foals, many of which were undoubtedly descended from the Digby and Villiers Arabians, the latter imported by James I. (No stallions are mentioned in the list of the stud made by Cromwell's Commissioners who visited Tutbury in July, 1649; it is supposed that the sires were removed in anticipation of the Protector's confiscation of the stud.)

Cromwell continued the Tutbury stud as a national institution, recognizing the importance of improving English horses; and though he discountenanced racing, he established a stud of his own and sent his stud master, Place, abroad to buy horses. Place is said to have been an excellent judge of horseflesh and a successful breeder; among other horses brought to England by him was Place's White Turk, a sire which wrought great influence. Matchem and Snap trace their descent to mares got by him.

There can be little doubt but that up to the time of the Restoration (1660) the breed of light horses for general use consisted of mixed blood. The vast majority of importations were stallions; and these crossed on English mares, and the progeny of such crosses being mated among themselves or with other Eastern importations, a strong strain of Eastern blood existed in the 17th century, before the arrival of the 'Royal Mares', with whose advent in England the real history of the modern Thoroughbred begins. Charles II (1660–85) was extremely fond of racing; he was a constant visitor to Newmarket, where he had a residence (The King's House) and ran horses in his own name. Taking keen, intelligent interest in the improvement of the breed, he sent his Master of the Horse, Sir John Fenwick, abroad to purchase stallions and brood mares.

The mares so purchased were Eastern blood only, Arabs, Barbs, or Turks, and described simply as 'Royal Mares'. The improvement in our racehorses which quickly followed the importation of these mares proves the judgment exercised by Sir John Fenwick in his selection. The greatness of the debt owing to these mares by the Thoroughbred is shown by the frequency with which 'a royal mare' occurs in the old pedigrees.

When Charles II died, the Royal Mares appear to have been sold. They found their way into the hands of owners in various parts of the country, and, thanks to the custom of calling imported horses by the names of their owners, the history of the breed is placed on a more definite basis. A considerable number of mares became the property of Lord D'Arcy, who laid with them the foundation of the fame of the Sedbury stud. Lord D'Arcy had founded his breeding establishment soon after the Restoration and owned two sires, the White D'Arcy Turk and the D'Arcy Yellow Turk, imported by himself. These sires and the Royal Mares, with others of Eastern descent, 'contributed most materially to the improvement of our breed of horses' (Horse-breeders' Handbook, Joseph Osborne).

The union of the White D'Arcy Turk and a Royal Mare produced Wilkes's Old Hautboy, perhaps the best sire of his day; the dam of Snake by the Lister Turk, the dam of Almanzor to the Darley Arabian, and of Terror to the Akaster Turk. The D'Arcy Yellow Turk, mated with another Royal Mare, got Brimmer, and, with Lord Fairfax's Morocco Barb Mare,

Spanker. All these names occur in the pedigree of Eclipse.

Among the sires imported in Charles II's reign must be mentioned the Curwen Bay Barb and the Toulouse Barb, both imported by Mr. Curwen of Workington Hall, Cumberland. The Bay Barb got Mixbury, the most famous Galloway of his day, and two mares, the elder of which became the dam of Partner Soreheels; Sister to Soreheels, Little Scar, and the dam of Crab. The Lister Turk was the most notable horse imported during James II's brief reign (1685–8); as the sire of Coneyskins and Snake, this horse holds an important place among foundation stallions.

We now come to the importation of the Byerley Turk (1689), the first of the three great Eastern sires. His best son, Jigg, sired Partner, who sired Tartar, who, put to Cypron, got Herod. Other good horses brought to England during William III's reign (1689–1702) were Chillaby and the mare Slugey or Sloughy, Morocco Barbs, sire and dam of Greyhound, who did valuable service at the stud, more especially through his daughters; the Selaby Turk, who also rendered greatest benefit through his daughters; the Harper Arabian and Akaster Turk, the latter of whom begot several good mares, Thwaites Dun mare among them; and the Honeywood Arabian.

Queen Anne's reign (1702–14) was an epoch in the history of the Thoroughbred, as among the twenty-four Eastern sires imported while this sovereign was on the throne, was the Darley Arabian (1706). The value of Eastern blood had now become fully recognized by breeders, and —'about the time of the arrival of the Darley Arabian in Yorkshire, there arose an extraordinary rivalry among the wealthy noblemen and gentlemen resident in the three great Ridings and in the neighbouring counties for the possession of Eastern blood, which not only increased as time went on but extended to other parts of the Kingdom: and to this circumstance is chiefly due the immense improvement that took place in our breed of horses during the early part of the last (18th) century' (Horse-breeders' Handbook, Joseph Osborne).

The Leedes Arabian was brought to England about the same time as the Darley Arabian, and in the opinion of the high authority quoted above, is entitled to almost as much credit for the improvement in the breed, which was brought about chiefly through the merit of his female progeny. Other sires which conferred lasting benefit on the breed were the Oglethorpe Arabian, the Bloody Buttocks Arabian, the White Legged Lowther Barb, and the Taffolet Barb.

It was during Queen Anne's reign that the Royal Plates were established. They were the gift of a private individual whose name has not been recorded, and were thirteen in number. The purpose of the public-spirited donor was to try and counteract the growing tendency of the day to breed horses for speed only, to the neglect of weight-carrying and staying powers; and to this end the conditions of a Royal Plate were the best of three heats over a four-mile course, carrying 12 stone. These plates were given at various Meetings at the discretion of the Crown, and, being regarded for a long period the most important events on the Turf, did something to encourage the production of stouter horses.

The importation of Eastern blood continued steadily during the first seventy years of the 18th century. George I (1714–27) seems to have taken little personal interest in racing, but the arrival of the Godolphin Arabian (1724) was an event of his reign. To this horse is given more credit for the improvement of the breed than any other sire imported before or since.

It is in no spirit of disparagement to the valuable services of the three so-called 'foundation sires', the Byerley Turk, Darley and Godolphin Arabs, that we suggest that to them has been given perhaps more credit for the improvement of the breed than is justly their due. The history of *progressive* improvement dates from a period earlier than the arrival of the first of these sires. The Royal Mares, imported in Charles II's time (1660–85), had been distributed among various private studs, notably the Sedbury, four years before the Byerley Turk arrived in 1689, and at least five years before that horse was sent to the stud. His owner, Captain Byerley, used the Byerley Turk as a charger during William III's wars in Ireland, and rode him at the Battle of the Boyne, July 1, 1690.

Great and steady improvement had been made before the Darley Arabian arrived in 1706 and the Godolphin in 1724; and credit for this must be divided between the less-well-known sires, the Royal Mares, and their progeny.

We may take up the history of the breed from the accepted starting-points — the three sires, Matchem (1748), Herod (1758), and Eclipse (1764)—concerning whom it is to be remembered that Matchem had the most Eastern blood in him and Herod least.

The Eclipse (or Darley Arabian) lines of blood may be first considered; they have shown such vitality that they threaten to outstay altogether those of both Matchem and Herod. There are four important 'lines', which may be set out thus:—

Eclipse.

Pot-8-os (1773).	King Fergus (1775).	Joe Andrews (1778).
Waxy (1790).	Hambletonian (1792).	Dick Andrews (1797).
Whalebone (1807).	Whitelock (1803).	(4) Tramp (1810).
	(3) Blacklock (1814).	

(1) Sir Hercules (1826). (2) Camel (1822).

The fifth line is that of Harkaway, viz.: Waxy (1790)—Whisker (1812)—Economist (1825) —Harkaway (1834); but of these little need be said. King Tom, son of Harkaway, begat Kingcraft, who won the Derby of 1870, and three

Oaks winners in Tormentor, Hippia, and Hannah; Foxhall was also a representative of this family, which 'is now little known in this country, though it has done well both in Australia and America' (Richardson).

The first of the four lines sketched above is that of *Sir Hercules* (or Birdcatcher). Sir Hercules begat Birdcatcher in 1838; and Birdcatcher's best sons were the Baron and Oxford. The line of the *Baron* follows:—

The Baron (1842)
Stockwell (1849).
Doncaster (1870).
Bend Or (1878).
- Kendal (1883). — Galtee More.
- Ormonde (1884). — Orme (1885).
- Martagon (1887).
- Orvieto (1888).
- Cyellene (1895).

Stockwell also sired Lord Ronald, Blair Athol, and St. Albans among other horses which achieved less distinction at the stud than Doncaster through Bend Or.

Oxford, foaled 1857, sired Sterling (1868), who sired

Isonomy (1875).
- Gallinule (1884)
- Janissary (1887).
- Isinglass (1890).

We have next to trace what is known as the *Newminster–Touchstone* line from Whalebone. His son, Camel, foaled 1822, begat

Touchstone (1831).
Newminster (1848).
- Hermit (1864).
- Lord Clifden (1860).
  - Petrach (1871)
  - Hampton (1872).

Hermit was the sire of many good sons and daughters: among the former, Friars' Balsam, Melanion, Ascetic, Heaume, and St. Blaise; among the latter, Penitent and Moorhen (dam of Gallinule). Hermit's descendants have been remarkably successful as steeplechasers as well as on the flat. Hampton was one of the most successful of modern sires. He begat, among others, Merry Hampton, Ayrshire, Ladas, Royal Hampton, and Sheen.

The third or *Blacklock* line may be sketched thus:—

Blacklock (1814).
Voltaire (1826).
Voltigeur (1847).
Vedette (1854).
Galopin (1872).
St. Simon (1881).

This, in Mr. Richardson's opinion, is probably the best staying family of the day, its greatest rival in respect of stamina being the Isonomy line of Birdcatcher. Voltigeur, it may be noted, had twenty-three strains of Herod blood against fifteen of Eclipse blood.

The fourth family, that usually known as the line of *Tramp*, is as under:—

Tramp (1810) begat Lottery (1820), who begat

Sheet Anchor (1832).
Weatherbit (1842).
Beadsman (1855).
- Rosicrucian (1865). — Beauclerc (1875). — Tyrant (1885)
- Cœruleus (1872). — Blue Green (1897).

Of 'Eclipse mares', the following must be mentioned: Penelope (Trumpator–Prunella); Pewet (Tandem–Termagent); Evelina (Highflyer–Termagent); and Pocahontas, who, however, has many strains of Herod in her pedigree.

The *Matchem* (or Godolphin Arabian) line need not detain us long. The fame of the original sire is perpetuated to our own day by a single line as follows:—

Matchem (1748).
Conductor (1767).
Trumpator (1782)
Sorcerer (1796).
Comus (1809).
Humphrey Clinker (1822).
Melbourne (1834).
West Australian (1850)
Solon (1861)
Barcaldine (1878).

The *Herod* (or Byerley Turk) family has been perpetuated by four branches, which may be conveniently set out thus:—

Herod (1758).
- Highflyer (1774). — Sir Peter (1784).
  - Walton (1799) — Partisan (1811) — Gladiator (1833). — Sweetmeat (1842). — Macaroni (1860). — Macgregor.
  - Sir Paul (1802). — Paulowitz (1813). — Cain (1822) — Ton (1835). — Wild Dayrell (1852) — Buccaneer (1857). — Kisber (1874).
- Woodpecker (1773). — Buzzard (1787).
  - Castrel (1801) — Pantaloon (1824) — Windhound (1847) — Thormanby (1857). — Charibert.
  - Selim (1802). — Sultan (1816) — Bay Middleton (1833). — Flying Dutchman (1846). — Upas. — Elf II (1893).

The Buccaneer branch is the only one to which importance attaches at the present time.

It does not seem necessary to trace the doings of scions of these families beyond the points at which they have been left. Space forbids the

writer to do more than bring thus baldly the past history of the breed into touch with the horses of the present day, leaving the reader to follow up the breeding of animals in which he may be interested.

THOROUGHBREDS ABROAD.—The *American* Trotting Horse is of mixed descent. The horses abandoned by de Soto in 1542 on the confines of Texas, half a dozen in number, are held to be the ancestors of the wild horses of North America. Thus nearly eighty years before English horses were introduced by the early settlers in Virginia, there was a large stock of Spanish blood; which blood is closely allied to, if not identical with, the Barb blood.

There were 'several shipments of horses at different times by the proprietors [of the colony of Virginia] down till about 1820' (The Horse of America, by John H. Wallace); and as it was the custom in Virginia and the other American colonies to brand the young stock and turn them loose, we may safely assume that these English horses interbred with the wild descendants of the Spanish horses. The Dutch and Swedish settlers obtained horses from Holland and Sweden in their turn; and in the latter half of the 17th century races were established on Hampstead Plains, Long Island. The first horses imported into New England reached Boston in 1826, and other shipments from this country followed. The first English racehorse is said to have been imported into Virginia about 1750, but no particulars of this animal are recorded. Certain English racehorses were imported about the year 1750. Of these, one named Traveller was the most important arrival; another named Janus did good service. Modern American Trotters trace their descent to Messenger, son of Mambrino, imported in 1788 when eight years old. Mambrino had been remarkable in England for his success in getting road and coach horses, and Messenger inherited the trotting powers his sire bestowed upon his progeny.

Messenger stood at various places, Philadelphia, in New York State, and in New Jersey, for twenty years, and got many good horses. Those that made the greatest impression on the breed were: (1) Bishop's Hambletonian (foaled 1804), out of Pheasant (the Virginia Mare), said to be by imported Shark; (2) Mambrino (foaled 1806), out of a mare by imported Sour Crout; (3) Winthrop, or Maine, Messenger (foaled about 1807), out of an unknown dam; (4) Grey Mambrino (foaled about 1800), dam by Pulaski; (5) Mount Holly, dam by Bajazet. Abdallah, by Mambrino out of Amazonia, one of the most distinguished trotters of her day, has been called the 'King of Trotting Sires' of his generation; he was foaled in 1823. Mr. Wallace gives a list of forty-one English stallions which were imported about the same time as Messenger. Among them are eight sons or grandsons of Herod, six sons or grandsons of Eclipse, four sons or grandsons of Highflyer; but as not one of the forty-one 'founded a trotting family, and no one of them ever got a trotter out of a mare of his own kind', they need not be further considered.

Messenger descends in direct tail male from the Darley Arabian; but there are blanks in the pedigree (dam's side) of his great-great-grandsire Blaze; and his trotting powers indicate a strain of Hackney blood.

Australasia.—The earliest exportation traceable is that of Steeltrap, sent to New South Wales in 1823. No regular record of Thoroughbreds exported was attempted until vol. iv of the General Stud Book was published in 1840. In that year Calendar and Vagabond were sent to Australia, and in course of the decade following half a dozen more. Vol. ix contains a list of fifty-five stallions and forty-six mares which had been sent to Australia during the year 1860 and earlier. Toxophilite (foaled 1855), sold to New Zealand by the Earl of Glasgow, was one of the most valuable sires ever sent to the Colonies. As the sire of Musket, who got many good horses, including Carbine, who was purchased in 1896 by the Duke of Portland, Toxophilite must hold a high place in the history of Australian horse-breeding. Fisherman, sent to Adelaide in 1860, is another horse deserving of special mention.

Cape Colony.—Squirrel, by Cain (exported 1839), is the first Thoroughbred mentioned as having been sent to South Africa. Several more were sent out during the ensuing twenty years, including Turpin, by Hetman Platoff, Bramble, by Bay Middleton, in 1845; Holloway, by Emilius, in 1847; and Pantomime, by Pantaloon, in 1850. Thirty-seven stallions and three mares were sent to the Cape during, and prior to, the year 1860 (vol. ix, General Stud Book).

Continent of Europe.—The demand for English Thoroughbreds appears to have begun in the early 'twenties of the last century. In 1823 Rainbow was sent to France. During the 'thirties and 'forties the demand from France increased, and such horses as Alington, by Gustavus (exported 1832), Cadland, by Orvile (exported 1833), Sir Benjamin, by Whisker (exported 1834), Dangerous, by Tramp (exported 1835), Theodore, by Comus (exported 1838), were purchased by our French neighbours; and many Thoroughbred mares were taken by them during the period 1850–60. The demand from the States which now constitute the German Empire took shape in the 'thirties. Erymus, exported in 1832, was among the earlier purchases; Brutandorf was sent to Germany in 1842, Mundig in 1843, and Elis in 1844. Many mares were sold to German buyers during the period 1857–60. Russia began to buy from us about 1823, in which year Soothsayer, by Sorcerer, Antar, and Interpreter were sent to that country. Many horses were sent to Russia during the 'forties, including Hymen, brother to Glaucus (exported 1840), Coronation (exported 1846), and Zanoni (otherwise Running Rein) in 1847. The earliest Austrian purchase traceable is that of Grimalkin, sold by the Duke of Rutland to the Emperor in 1814. Cardinal Puff, Carthaginian, Clincher, and Old Dan Tucker went to Austria in 1852. Buccaneer, sire of Kisber, sold in 1865, was one of the most noteworthy exports to Austria-Hungary.

Thoroughbreds have also been sold to Sweden, Holland, Spain, Italy, and other countries during

the last fifty years. It is to be observed that the great majority of Thoroughbreds exported to the Continent are purchased by the respective Governments, the purpose being to improve the native breeds, not to produce racehorses.

Height and Conformation.—The modern racehorse differs very widely from his ancestors of two centuries ago, both in height and conformation. The Arab and Barb stallions and mares which played so large a part in making the breed were animals of 14 hands or little more; and there is good reason to believe that English 'running horses' of that period were little, if at all, bigger. Old Turf records indicate that 14 hands was the average height of the racehorse. In 1711 a Plate at Newmarket was advertised, each horse, mare, or gelding to carry 10 st. if 14 hands high, if above or under to carry weight for inches. In 1750 the conditions for a £50 Plate at Newmarket were framed on the same lines, '14 hands to carry 8 st. 7 lb'. Heber's Calendar of 1752 is the first work of the kind which contains a Table of Weights to be carried in the 'Give and Take Plates'; and this provides for horses of from 12 hands to 15 hands high, clearly indicating that these were the extremes it was necessary to provide for. Height was a point seldom mentioned by the old authorities unless the animal was exceptional in one direction or the other. Thus it is recorded of Mixbury, by the Curwen Bay Barb, dam by Old Spot (*temp.* Charles II), that he was only 13·2. Gimcrack (foaled 1760) was 14 hands and quarter of an inch. The advertisements of stallions which appear in the old Calendars are helpful as regards horses of a later period. We find Bosphorus, by Old Balram, dam by the Hampton Court Old Childers, advertised in 1768 as '*upwards* of 15 hands high'. In the same volume (Heber's Calendar) the following stallions are advertised: Young Traveller, 'full 15 hands high'; Sloe, 'full 14 hands 3½ in. high'; Second, 'very near 14 hands 3 in. high'; Torresmond, 'very near 14 hands 3 in. high'. The 'Bay Horse call'd Babraham' is also advertised as 'full 16 hands high', but this assertion must be accepted with great reserve.

Though so much smaller than the modern Thoroughbred, the racehorse of that period possessed valuable qualities. He was required to carry as much as 12 st. in races of three or four miles run in three heats, sometimes more, on the same day at intervals of half an hour between the heats; and with these requirements in view he was bred to meet them. Thus he was more compact, better coupled, and had greater stamina; and was almost as much used to get hunters and roadsters as to get racehorses, which by virtue of his stoutness and general conformation, not less than his courage and speed, he was well fitted to do. The writers of a century ago make frequent reference to the services of racehorses for general stud purposes, and it would seem to have been the exception rather than the rule to keep a stallion exclusively for the service of racing mares. For example, it is recorded of Mambrino (1768) that he was 'the sire of many excellent hunters and strong useful road horses'. Bosphorus, the horse above referred to, advertised in Heber's Calendar of 1767 to cover at three guineas a mare at Mr. Haswell's, Epsom, is described as 'not only likely as any horse in the Kingdom to get a Racer, but a Hunter or Coach-horse, or according to his mares'. Few Thoroughbreds of our own day would be chosen by the judicious breeder as sires of weight-carrying hunters.

The change in the direction of increased height of racehorses would seem to have begun about the end of the 18th century. It was at this period that two-year-old racing, advocated by Sir Charles Bunbury, came into vogue, and the practice brought in its train as a necessary consequence the system of 'forcing' the growth of young stock in order to make them the sooner ready for the racecourse. An anonymous author writing in 1836 refers to the marked increase in size which had then taken place: 'The intelligent reader must perceive that the great size so much admired by the public in brood mares has been acquired . . . The English racer, we cannot doubt, acquired his enlarged structure by rich food.' The writer was of opinion that the horses of his day were inferior to those of fifty years earlier in respect of stoutness, ability to carry weight, and in staying power. The system of heat racing was declining in the 'thirties, and the programme of any Meeting bore greater resemblance to the 'card' of the present day. Increase of the practice of racing young horses under light weights, together with abandonment of heat races under heavy weights, between them brought about the endeavour to produce a bigger horse able to gallop fast for a short distance under a light weight. This tendency which had borne fruit seventy years ago has continued down to our own time, the long-striding animal sought having been gradually brought to its present conformation. It is very doubtful whether the *average* height of the racehorse in the 'thirties exceeded 15 hands, though we need not doubt that individual horses of greater height occasionally occurred.

The late Admiral Rous has shown that the average height of our Thoroughbreds had increased at the rate of 1 in. in every twenty-five years. The increase has been more rapid during the last hundred years than during the hundred years preceding it, but in the main the assertion of the Admiral holds good. The late Mathew Dawson 'considered it demonstrable that within the experience of living persons the size of the racehorse has increased in this country' (Richardson, The English Turf). The increase in height has been by no means an unqualified advantage. Granting the truth of John Scott's oft-quoted maxim that 'a good big one will always beat a good little one', we have to bear in mind William Day's remark (The Racehorse in Training) that 'as a rule you may get fifty good small horses for one good large one, and the former will, and do, run well after the latter has been put to the stud'.

The same high authority held (The Horse: How to Breed and Rear him) that little stallions put to suitable mares get much better stock than most large horses; and he cites

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Photo F Babbage

THOROUGHBRED STALLION—"LEMBERG". DERBY WINNER, 1910

Stockwell as the only thoroughly good *large* stallion he had known within forty years.

Our entire racing system has undergone a great change in the last hundred-and-twenty years. In the old days, horses were not raced until they were four, five, or even six years old; during our own time they are very generally sent to the stud at the age when, in former times, they were only beginning their active career on the racecourse. This change, bringing about the forcing system already referred to, must be held responsible for the falling-off in constitution and soundness. Yearling colts, nowadays, appear in the sale ring nearly a hand higher than they would have been if reared under natural conditions; hot stables, soft food, and general pampering results in rapid growth and accompanying defects. The horse thus reared, like a child too tall for its age, is delicate and 'soft'. Notwithstanding the care bestowed by the skilful trainer, the work required of it finds out weak spots and develops latent unsoundness. It is very doubtful whether the forcing process affects the ultimate growth of the horse; in all probability the animal simply attains its maximum growth at an unnaturally early age. (The natural growth of the horse in its first year is exceedingly rapid. The writer is indebted to Professor Cossar Ewart for figures which show that a colt born of parents each exceeding 15·2 in height, was 9·0¼ at time of birth and measured 13 hands when one year old; this despite the fact that it 'did badly' during its first year, probably because the dam was out of condition and could not nourish it properly. When three years old this colt stood 15 hands, having made up lost ground in its second and third years.)

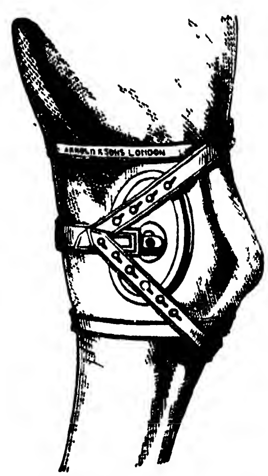
It is only reasonable to assume that Nature ordains a certain normal average size for any given breed, and, endowing the animal with a measure of vitality coinciding with the normal average size, does not increase that measure of vitality in response to the demands of *artificial* enlargement of frame. Hence, when by careful mating, rich food, and a hothouse system of forcing growth, the frame is enlarged at an abnormally early age, that larger frame is more liable to disease and more likely to suffer from the effects of exposure and hard work. Our modern racehorses are bigger and no doubt faster over a short distance than their ancestors, but they lack their ancestors' stamina, soundness, vitality, and weight-carrying power.

The same results of early racing and short races under a feather-weight are to be seen in the Australian Thoroughbred. The demand for a speedy sprinter has brought about the production of light, long-limbed horses, which can make wonderfully good time over four or six furlongs under a light-weight; but the stout saddle horses, peculiarly valuable in that country of great distances, which were formerly bred from blood stock, have almost disappeared.

COLOUR.—The Arabs, Barbs, and Turks from which our racehorses so largely trace their descent were of very various colours. Less than a third of the number enumerated by Mr. Osborne in the Horse-breeders' Handbook are described by colour; but so far as this proportion enables us to judge, grey was much commoner than it is now. There are 16 grey horses, 11 bay, 8 chestnut, 4 black, 3 dun or yellow, 2 white, 2 brown, 2 roan, 2 piebald or particoloured, and 1 bay roan. This variety of colour is reflected in the pages of the early Stud Books and Racing Calendars: greys, blacks, and particoloured horses were much more numerous on the Turf a century ago than they are in our own day, when, so far as England is concerned, grey and particoloured horses have practically disappeared, while blacks are rare. The period 1760–1800 saw some of the best grey horses that ever ran: Gimcrack, Mambrino, Grey Diomed, Kildare (an Irish horse), Hollandaise and Symmetry (winners of the St. Leger in 1778 and 1798 respectively). Grey horses become fewer as we examine the records of the last century; the only grey sire now serving, so far as the writer is aware, is Grey Leg. Horses of this colour have grown rare because we have not within memory had a grey sire of outstanding excellence to perpetuate his kind.

Chestnut, formerly an uncommon colour, has gradually become more frequent. It is worth noticing the fact that Eclipse was a chestnut, and it is a commonplace of the Turf that Eclipse blood is asserting its greater vitality over the blood of Herod and Matchem. Blacks are now unusual; when the colour does occur, it indicates with certainty descent from the black Byerley Turk. This colour is prone to disappear for a generation or two and appear again. Bay and brown, varieties of the same colour, are now, as for many years past, the common hues of our Thoroughbreds; and the predominance of bays seems to furnish evidence in support of the theory that the colour of the ancestral horse was bay. [W. G.]

Thoroughpin



Compress for Thoroughpin

Thoroughpin.—A soft fluctuating swelling at the upper and posterior part of the hock, beneath the great tendon (extensor pedis), is known by this name, and is a bursal enlarge-

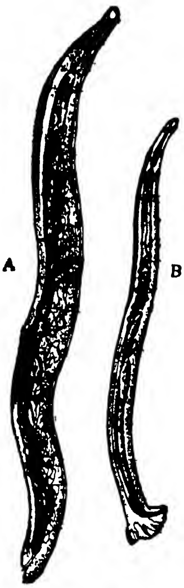
ment. It may appear on one side only, but more frequently on both. Two kinds are distinguished—one by sprain and irritation of the tendon; and the other from similar conditions affecting the true hock joint, and often an extension of the condition known as bog spavin. An excess of synovial fluid which must bulge where it can, and taking the line of least resistance, is a description which applies both to bog spavin and the two forms of thoroughpin, but they vary greatly in extent and degree. Lameness is so often absent that the enlargement is generally observed without any history of known sprain or trouble; but some degree of stiffness, of heat in the part, and an attitude intended to favour the joint, must have been present at first. Although constituting technical unsoundness it is often passed over by practical horsemen, as it may remain about the same for years, while the animal continues to work sound. As a rule, however, it increases. Blistering generally confers benefit, both at the time, by some reduction of the swelling, and subsequently, by thickening the skin and strengthening the parts. [H. L.]

Thousand-headed Kale.—The attention of agriculturists was first drawn to this valuable fodder crop by the late Mr. Robert Russell of Horton Kirby, Dartford, Kent, in 1876. Mr. Russell drew special attention to its luxuriance and adaptability for all kinds of soils, and also to its importance, as both a spring and autumn fodder. He recommended it to be sown in April for August consumption, and in August for April consumption—a system which provides an ample amount of fodder at two critical periods of the year. So completely has the name of the introducer of this crop become identified with it, that to this day the most approved seed is described as Russell's stock.

Thousand-headed Kale belongs to the class of open-headed cabbages. The distinguishing title 'thousand-headed' refers to its numerous buds at the axils of every leaf, which branch out during the development of the plant and form a dense globular mass of foliage. It is in some respects similar to rape, but the leaf is more cabbage-like, being oval and less lyrate in form, besides being of a lighter-green colour, and free from the blue-green or glaucous tint of rape. It grows very vigorously, often rising (before flowering) to such a height that a man can put the leaves between his teeth without stooping. It attains its maximum development on good land, after having been singled, but it may be grown on poorer classes of land. In the latter case it is better left unsingled, and when so grown forms a solid mass of vegetation particularly suitable for ewes and lambs. It may also be mixed with rape or white turnips on high-lying ground, with excellent results.

The roots are very strong and 'fangy', especially after the crop has been singled, and this constitutes an objection, although easily overcome. The same tendency also probably accounts for the plant being thought less suitable as a preparation for corn than rape, as the roots carry off a considerable amount of fertilizing matter when removed, as they almost must be. The depth and strength of the roots enable the plant to produce a second or even a third crop after folding, and it has been said to be even capable of standing for an indefinite time, producing folds for sheep at intervals, during its occupation of the ground. It is extremely hardy, and successfully resisted the intense frost of 1895, when even rape died, and swedes rotted. The cultivation is exactly the same as for rape, and 3 cwt. per acre of superphosphate drilled with the seed is sufficient manuring. Like all crops, it is benefited by a dressing of dung. Three pounds of seed are usually drilled, in rows from 18 to 27 in. apart. [J. WR.]

Threadworms (Nematoda), a class of worms with the following general characters. The body is unsegmented, more or less thread-like or stringlike, cylindrical in cross section; the skin is covered with a smooth or slightly ringed cuticle, often thick, usually unpigmented, and in many cases subject to moulting; the muscular system is well developed and consists of elongated muscle-cells arranged longitudinally, and often leaving two free 'lateral lines'; a nerve ring round the gullet gives off nerves forwards and backwards; the sensory system is represented by papillæ round the mouth; the alimentary canal is usually well developed; there is no vascular system nor respiratory system; two lateral excretory tubes open far forward by a single pore; the sexes are usually separate, the males are often much smaller than the females; the life-history is in many cases very intricate. Many of the Nematodes live in water (fresh and salt), damp earth, and decaying organic matter; the others are parasitic during part or the whole of life. Of the latter, some are free as larvæ and parasitic as adults, *e.g.* Tylenchus and Strongylus; others are parasitic as larvæ and free as adults, *e.g.* Mermis; others are parasitic throughout life, and in most cases require two hosts. The following representative types may be noted: *Ascaris megalocephala* from the horse, *Oxyuris curvula* from the horse, both in the family Ascaridæ; Strongylus in horses, cattle, sheep; *Eustrongylus gigas* in the kidney of the horse, *Dochmius cernua* in sheep and goats, *Syngamus trachealis* causing gapes in poultry—all in the family Strongylidæ; *Trichocephalus affinis* in sheep, *Trichina spiralis* in rat, pig, man, and other hosts, both in the family Trichotrachelidæ; *Filaria immitis*, the cruel worm in dogs, *Spiroptera reticulata*, round tendons and muscles in horses, both in the family Filariidæ; Mermis, that creeps out of



Dochmius duodenalis

A, ♀. B, ♂.

grasshoppers, caterpillars, and other insects when mature, and creeps up the stalks of plants, a type of the family Mermithidæ; *Tylenchus tritici*, causing 'ear-cockles' in corn, *Heterodera schachtii*, causing beet-sickness, *Anguillula aceti*, in decomposing vinegar and paste—three examples of the Anguillulidæ. See ASCARIS, GAPES, NEMATODES, STRONGYLUS, TRICHINA, &c. [J. A. T.]

Threshing, or the separating of the grain from the ear, is now almost entirely done by power-driven machines. The flail is now rarely used except for threshing small quantities, where it would not be worth while going to the expense of getting the aid of a threshing machine; or for procuring pure stocks for seed purposes; or, as in the case of peas and beans, to avoid the splitting which machines are liable to cause, and thus render them unfit for sowing. The flail (see FLAIL) is a very effective tool when its weight and simplicity are considered, but unless corn is very bold and in good condition the threshing is not so thorough as when done by a modern machine; on the other hand, the straw is much better appreciated by animals, and makes better fodder. Hand-power threshing machines have never been used to any great extent, as the output is small, and the flail is sufficiently effective to deal with small quantities. Treadmills made to operate by means of an endless staircase, or rotary steps, and turned by the weight of men or horses, have been used to supply power, but few are in use. Horse power has been very extensively used in connection with horse gears, and where holdings are small and the farms not easily accessible to heavy sets of steam tackle, they still obtain to some extent, though the introduction of light oil engines is fast setting them aside. Horse gears practically necessitate a fixed threshing machine owing to the need of otherwise putting down a fresh horse-walk and removing the machine, which entail a considerable amount of trouble; all corn to be threshed has therefore to be taken to one place, which is not always convenient or economical. Water power, where it exists conveniently, is valuable and reliable, and cheap to use. It possesses the same drawbacks as horse gears in respect to its being a stationary power; but after a plant is once installed, the expense of its upkeep is very small. Wind power is too intermittent and unreliable, otherwise it would compete closely with water. Electricity has as yet been little used, and until some more simple means of employing it is found, is not likely to be made use of to any great extent for threshing. Internal-combustion machines, either fixed, portable, or in the form of motor tractors fitted with a driving pulley, are now fast gaining popularity on the farm, and cannot fail to largely supplant steam engines for threshing purposes.

Except where the machines and corn are under cover, threshing is essentially work which requires to be done in fine weather; as the corn comes out more readily, is in better condition, and opened ricks are not spoiled through insufficient covering, as is often the case when rain stops threshing before a stack is finished. In working a machine capable in ordinary circumstances of doing eighty or more sacks of an average crop of wheat in a day, the following hands are required. Engine driver, feeder, 2 men on stack, 1 cutting bands, 2 on straw stack if elevator is used (if an elevator is not used and the straw is stacked close to the beaters, 4 or more as the size and height of the stack require; or if the straw is tied by a single straw band, 1 man and lad making bands, and 2 tiers additional); 1 man at sacks, 1 at chaff, 1 at cavings (the caving man should help load sacks of corn on to carts), 1 water and coal cart, 1 carting away corn. Boys or lads may take a man's place in the lighter jobs. Loose corn requires an additional man on the stack. If corn is carted from a distant stack, an extra man is required to empty the load on to the machine. However, in an ordinary case 12 hands are required. As the work calls together a considerable number of hands, it is important to see overnight that all is in readiness to commence as soon as the steam is up. Sacks, coal, water, water tub, and ordinary tools should be in readiness, or valuable time will be lost.

Clover-seed threshing is important work in some districts; and its success depends much on the dryness of the stack and of the weather. The getting of the seed requires two operations: (1) the threshing of the haulm carrying the seed heads to knock off the heads and break them up, so that the cob (parts containing seed) are easily sifted out; and (2) the rubbing, hulling, or drawing where the seed is rubbed clear of the pods and chaff, which are then blown out, leaving a roughly clean sample of seed. Generally two separate machines are used; but there are machines with the combined parts to thresh and rub which work with efficiency. If the cob is stored, great care must be taken that it lies lightly; and the heap should always be made (under cover) by gently emptying the skeps or fans from above. Rubbing should be commenced as soon as possible. Where combined machines are used, there is the disadvantage that the threshing must be regulated by the rate at which the clover can be rubbed, and this is very variable.

Turnip seed, and seed of other cruciferous crops grown on the farm, are rarely threshed by machine; iron field rollers drawn by horses being run over wads of the haulm laid on big sheets in the field. On turnip seed-growing farms as many as twenty-five hands are commonly employed at once in threshing and cleaning on the cloths, and it is carried out with a smartness which exceeds any work done on the farm. Mangold seed is more commonly threshed by machine. [W. J. M.]

Threshing Machinery.—The essential parts of a threshing machine are a rotary drum fitted with fixed fluted beaters, and an adjustable open barred concave partly encasing it; all other parts are designed to clean the grain, and make other convenient separations. Crude methods had been designed to beat the straw and ears so as to set free the grain; and even a series of mechanically actuated flails had been tried; but

it was not until Andrew Meikle of Whitekirk, East Lothian, patented his revolving drum working in a concave, in 1788, that anything of practical value was evolved. This is one of the most notable and most valuable inventions yet produced. Meikle's machine was successful where its predecessors were not, because it combined both a striking and a rubbing action. All threshing is now done on this principle in which the squeezing action plays so great a part. Meikle's principle separated the straw from the corn by means of a jogging screen; and used two blasts, the first blast separating the chaff, and the second freeing the grain, after passing through a hummeller, from impurities. There were therefore the elementary foundations for the cleaning parts which are found in the 'finishing' machines of to-day. The modern straw shaker, where the straw is received on a series of long slatted arms placed parallel on cranks which produce a somewhat peristaltic action by giving them a throw which, whilst going forward, causes each to alternately rise and so lift the straw onward, and whilst going backward to sink, so that it does not hinder the forward motion of the straw, was invented between 1829 and 1837, Docker of Findon claiming the first date, and Ritchie of Melrose the later. The threshing machine, which is also spoken of as the drum, the barn part, the mill, the thresher, &c., in various districts, is now capable of handling a crop in such a way that, whilst making all needful separations in connection with the straw and foreign

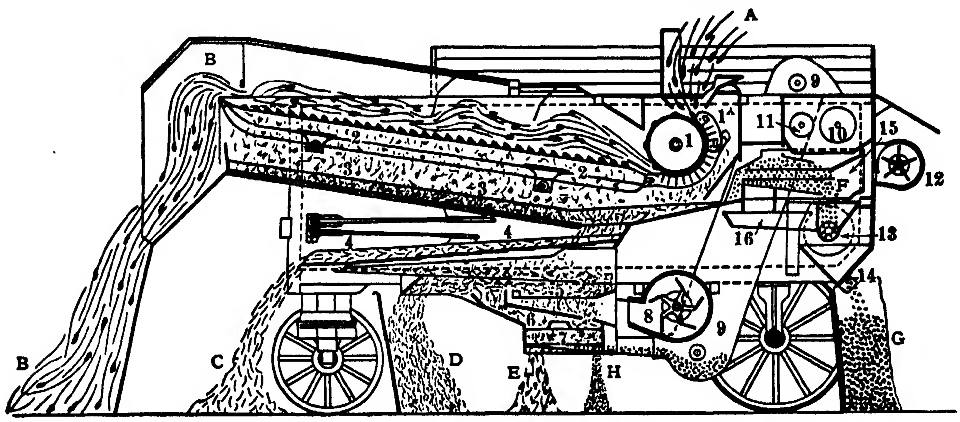


Fig. 1.—Sectional View of Finishing Threshing Machine (Brown & May, Ltd.)

A, Unthreshed Corn. B, Straw. C, Cavings. D, Chaff. E, Chobs. F, Corn. G, Finished Grain. H, Dust. 1, Drum. 1A, Concave. 2, Shakers. 3, Upper Shoe. 4, Caving Riddle. 5, Chaff Riddle. 6, Chob Riddle. 7, Seed Sieve. 8, First Blower. 9, Corn Elevator. 10, Awner and Polisher. 11, Conveyor Worm. 12, Back Blower. 13, Separating Screen. 14, Corn Spout. 15, Second Dresser. 16, Third Dresser.

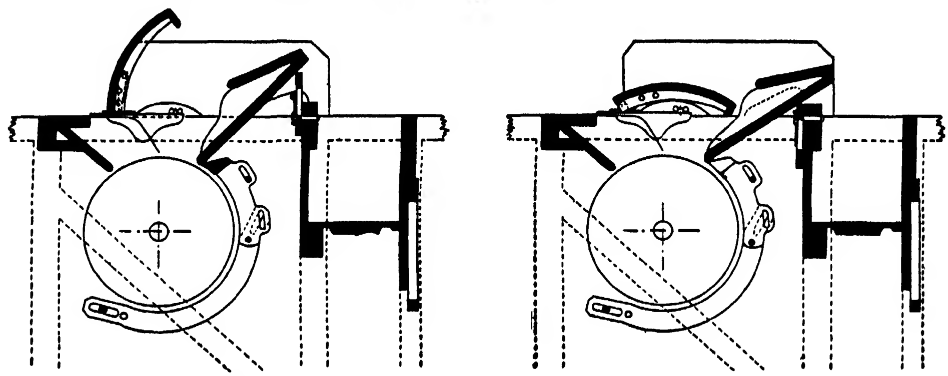
matter, it turns out a sample of corn so well dressed that it is fit for market; though more simple machines are still made which, whilst effecting good threshing, do not aim at making a market sample, nor are they so complete in their other separations; they are, however, generally constructed to be worked by small power, such as hand, horse, or small engine.

The working parts of the threshing machine are to a great extent encased, and the process of a sheaf through it is not easily followed. The illustration (fig. 1) is a sectional view of Messrs. Brown & May's finishing machine, which shows the order adopted in the best machines. To make it more easily understood, it has to be recognized that after the sheaf is broken up and threshed, which is done as it passes through the drum and concave, the straw passes along the shakers and falls out at the front of the machine. No further heed need therefore be taken of the straw. All the remaining materials go on to the cavings screen; and the cavings are expelled and therefore are finished with. The smaller material left behind is chaff, corn, and small rubbish. When the chaff meets a blast, it is blown out; consequently, there remains nothing but the grain and its heavy impurities, so that, from this stage, all operations are directed towards the cleaning of the grain.

The details of the process from the commencement are, that the sheaf is led into mouth of the machine, and is dragged in by the revolving drum, 1, the beaters of which are fluted, so that whilst exercising force to beat, and rub against the bars of the concave, 1A, they allow the grain to adapt itself in the indentures so that it is not crushed, as it would be if brought violently between two hard surfaces. The threshing is completed whilst passing through the drum and concave, much of the corn falling directly downwards towards the caving riddle, 4; the other passes along with the straw to the shakers, 2, where it is shaken through with the cavings, chaff, and other small material to the upper shoe, the straw passing out at the front. The upper shoe, 3, is a reciprocating receiving board which shakes back anything which falls on to it towards the middle of the machine, where it falls on to the caving riddle, 4, which reciprocates in such a way that it sifts through anything that will pass through its perforations, but carries the remainder, the cavings, forward, where they

fall under the straw; the chaff and corn fall through on to the lower shoe, another reciprocating board, which works them towards the middle of the machine again, where they fall on to a series of sieves, 5, 6, and 7, meeting there a blast of air from the fan 8, which blows out the chaff, and leaves nothing but grain and heavy small material behind: thus the stage is reached where subsequent operations are confined to the cleaning of the grain. Riddle 5 is the chaff riddle; 6 the chob riddle, which takes off poppy and thistle heads, pieces of stick, &c., which have reached this point; but it allows the small heavy seeds and particles of dirt to pass through on to 7, the seed riddle, which holds up the grain, but allows small seeds such as Charlock and Dock, and dirt of similar and smaller size, to pass out at H. This constitutes the first cleaning. In connection with the operations after the short material passed through the openings in the shakers, it may be noticed that the upper shoe, caving, and riddle, lower shoe, the chaff riddle, and the series of sieves below, are so suspended on ash hangers that, in spite of their great size and weight, they are actuated with little effort. If these parts oscillated in guides, which would cause great friction, especially in such dusty surroundings, they would consume much power; however, the suspension allows motion without friction, and with much ease.

The corn having received its first cleaning when it passes over the seed sieve 7, is shaken down the shaker shoe into the bottom of the case enclosing the corn elevator, to undergo further cleaning. The elevator is a continuous belt carrying dredging cups, and works over an upper and lower pulley. The corn is thus taken again to the top of machine at the rear of the drum, so that it may be dealt with in another



Drum Guard, open　　Drum Guard, shut

Fig. 2.—Safety Drum Guard

cleaning section. It may be noticed here that the space within the threshing machine is divided into three sections—(1) the upper portion in front to eliminate straw and chaff, (2) a small section below 1 to the first dressing, (3) the space behind the drum to the second dressing and finishing. The corn leaves the elevator, 9, to pass into the awner (hummeller or haler) and polisher, 10, a combination of beaters and chilled-iron disks running in a metal case with corresponding serrated rings, which take off any chaff which adheres to wheat, or awns not broken from barley kernels, at the same time brightening the grain by rubbing. When it is not necessary to use the hummeller, the corn passes direct to the second series of sieves by means of a conveyor worm, 11. A second blast is provided by a fan, 12, which operates upon the corn as it passes over the sieves 15 and 16, and any rough material is blown forward, and by means of a guide is sent on to the caving riddle, 4. The corn, F, is now practically clean, and passes to the rotary screen, 13, for final separation. In this particular machine a third blower is used, being placed on the end of the awner spindle to remove any light particles which may have escaped; this is brought to bear on the grain as it enters the rotary screen. The corn enters the cylinder of the rotary wire screen, and, in passing along, all those grains which are too large to fall through are conveyed to the other end, and drop into the corn spouts. This is the cleaned sample. The thin or tail grains, which fall between the bars of the screen, fall into the tail-corn spouts; those nearest to the entry naturally being the smallest, are the tail proper, and those falling later are known as seconds. This completes the whole operation; but there are several special attachments which are used with more or less frequency to accomplish specific purposes; most of these are supplied to the best types of machines.

Ordinarily, feeding is done by a man standing in a sunk hole, the feed-hole running alongside the drum, where he is conveniently placed to control the feeding. Owing to the danger and the numerous serious accidents which prevailed when nothing was provided to keep the feeder from falling in, drum guards are now compulsorily provided. They are generally of such construction that if a man applies a portion of his weight the cover is brought over the drum, and accident avoided. Automatic feeders are increasingly used, and take various forms. In Wilder's automatic feeder the sheaves, after the bands are cut, are spread on the shaker boxes,

and carried by them under the vibrating fork, which feeds the corn evenly into the drum mouth. Messrs. Clayton & Shuttleworth combine the self-feeder with a sheaf elevator, band cutter, and a wind stacker, making an essentially modern machine. The Plate gives a good idea of the arrangement. The elevator is removable, and can be attached to either side of the machine; and the pitch is easily altered by means of the suspender. The band cutter has a series of knives on a spindle, which cut the band and spread the sheaf as it moves forward to the feeder. The feeder is fitted with an efficient governor to control the rate of feed, and feeding does not start until the speed of the threshing drum rises within 5 per cent of the normal rate. The windstacker is used much more abroad than at home. The straw falls into a large fan revolving at high speed; the fan is provided with a hooded spout through which the straw is blown and carried on to the stack.

The threshing drum is made of metal throughout, instead of with steel fluted plates sitting on wood. This is practicable because the plates are flanged so as to give a big rubbing surface; and being a smooth surface it threshes clean without unduly breaking the straw. The drum is in a fixed position; consequently, to afford opportunity to regulate the distance between the drum and the concave, the latter has to be adjustable, and is made in two parts having three independent adjustments. Loose corn requires a wider feeding mouth than sheaved corn, and the adjustments allow this to be provided for. Indicator plates at the side of the machine provide ready means for accurate adjustment. The arms or boxes of the straw shakers are carried on a single or double crank; preference may be given to the double because they are more easily balanced and the straw is more vigorously acted upon over the whole surface. Check boards are placed over the shakers to prevent grain being thrown out by the force of the beaters. The riddles are perforated in a special manner, with the under side of the perforations broadest, to allow the material to pass through freely and avoid blocking. The illustration shows the method of arranging the caving riddle and the sieves in the first dresser, together with the fan and the direction of the blast. The corn riddles are changeable to suit the nature of the crop being threshed. The adjustable barley awner, comprising the helical blades and polishing bars, is shown; and the degree of polishing can be regulated by moving them so that they approach nearer to or farther from the narrow end of the conical casing; provision for effecting which is made by the small hand wheel working a threaded screw. Much harm is often done by not properly regulating this attachment, especially in the case of barley, where too hard rubbing skins the kernel so much that it becomes useless for malting purposes, as it will not germinate.

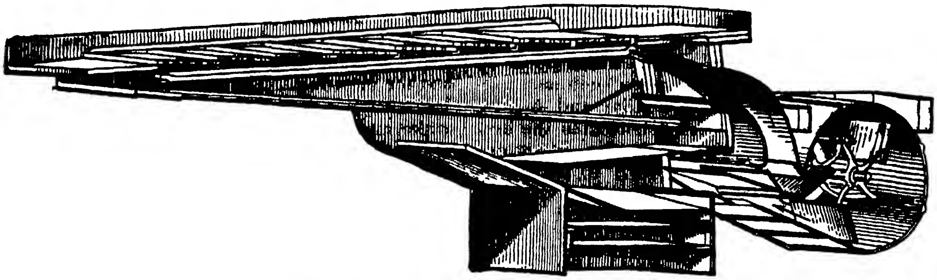


Fig. 3.—Section through Patent Divided Blast

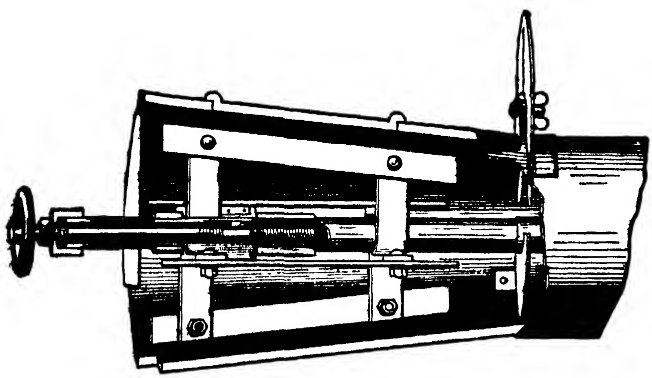
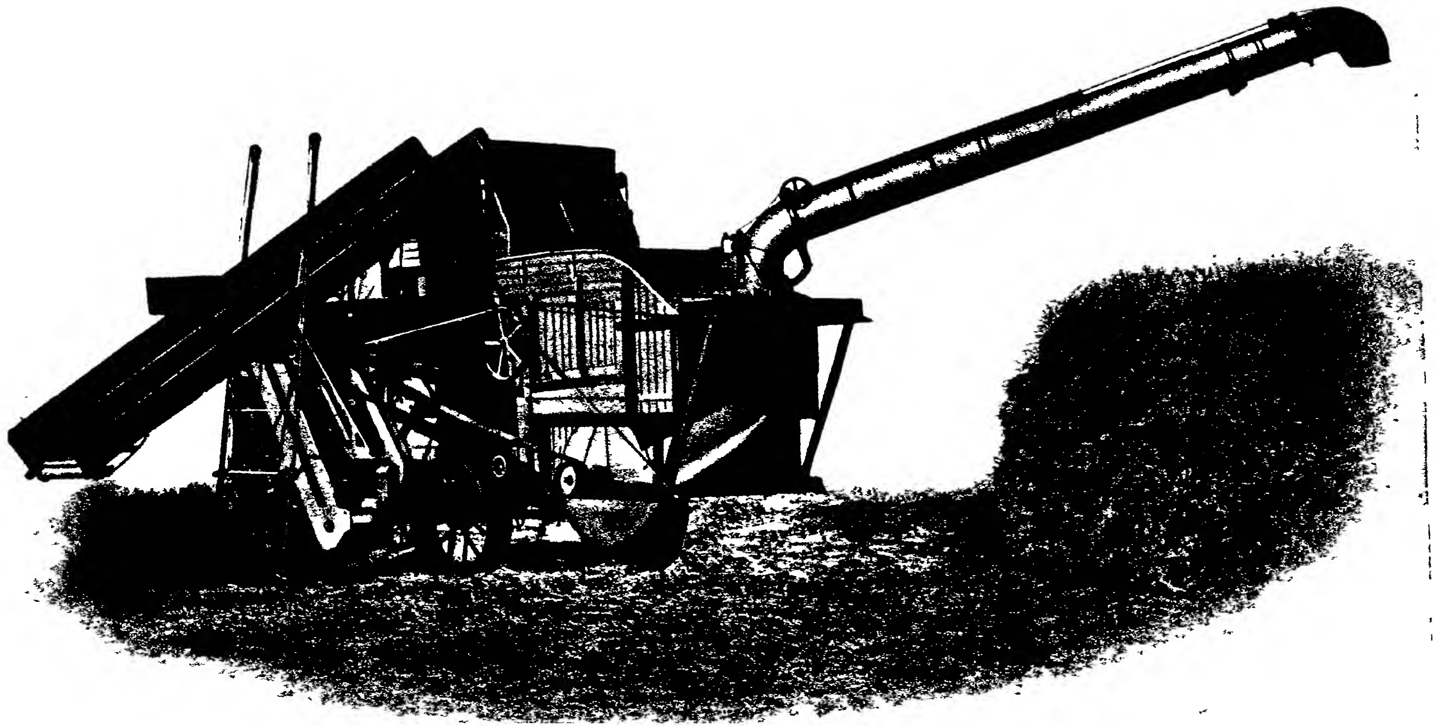


Fig. 4.—Section through Adjustable Barley Awner

The rotary screen is so constructed that the space between the wires throughout its length can be adjusted to screen small seeds or anything up to the size of peas. This is effected by means of a screw contained in the hollow shaft or spindle, adjusting springs inside the mesh causing the wire to expand evenly at all parts, according as the setting screw gives space. Round wire has been used, but wire with a somewhat truncated pear-shaped section is better as being less likely to block.

It is now pretty general to attach a chaff bagging attachment to machines, instead of allowing the chaff to fall to the ground; and in many cases this is advantageous. Straw ele-



FINISHING THRESHING MACHINE

Fitted with Sheaf Elevator Band Cutter and Feeder, also with Windstacker for straw

(Clayton & Shuttleworth, Ltd.)

[illegible]ters, introduced in 1802, are included in all [illegible] of threshing tackle, and tend to increase the quantity of work done daily. Their chief objections are that they are heavy, costly, and liable to get out of repair quickly—unless carefully tended—and to harbour dust in the trough, which on wetting becomes mud and causes rapid decay. In America light elevators are attached to the framework of the machine, hinged so as to easily fold back over the drum for transit; and this is better than the heavy stackers in common use in Britain. On farms, however, the stacker is generally needed for stacking corn or hay during harvest, consequently there is not the inclination to purchase the two kinds. It is not uncommon now to attach a straw trusser to the machine, so as to take the straw from the shakers, and bind it for transport. Double-string trussers are useful, and commonly used. Single-string trussers are available, and are useful for many purposes on the farm, but the trusses are not sufficiently neatly or securely bound for rough transport. The trusser is an adaptation of the principles of the sheafer and binder of the corn binder. Where straw is needed for export the baling press is a useful adjunct. One of the most useful attachments is the chaff cutter, but it is necessary to employ the large five- or six-knife machines, as the straw has to be chaffed as fast as it can be passed through the thresher. See CHAFF CUTTERS.

A clover-rubbing drum, the essential part of which is a revolving core with helical edges working in a conical concave, is attached to some threshing machines. Until comparatively recent years a solid core was used; but this is found unnecessary, and a hollow, helically ribbed core is more effective. The huller, rubber, or drawer is used to rub out the seed from the pods, which with other parts of the seed-head form the cob. [W. J. M.]

Thrips, a remarkable group of insects for which a separate order, Thysanoptera, has been

Thrips

1–4, *Thrips cerealium*; 5–8, *T. minutissima* (both natural size and magnified)

constituted. They are of small size, with four narrow fringed wings, elongate bodies, and feet ending in sucking disks, whence the German name Bladder-foot. They are sometimes popularly known as Black-fly, or Thunder-fly. The larvæ resemble the adults except in colour and in the absence of wings. They injure plants by sucking the sap, and their very small size makes them difficult to deal with. They are sometimes very troublesome in hothouses, and a few outdoor crops are particularly liable to attack. The best-known species is *Thrips cerealium* (Hal.), an active little black insect, which resides in the spathes and husks of wheat and rye in June, causing the grain to shrivel, and at an earlier period effecting the absorption of the ear, by puncturing the stems above the joints, being most injurious to late-sown wheat. In the larval state they are deep-yellow.

T. minutissima (Linn.) lives beneath potato leaves in the summer, and subsists upon the sap. It is of a pale-yellow colour in all its stages.

Another very destructive species is the Pea Thrips, *T. pisivora*, which attacks the developing pods, greatly disfiguring them, and in bad cases ruining the crop. The larva is yellow with a black tail, but the mature insect is black. The eggs are laid in the substance of the stamen sheath in the pea flower. [J. C.] [C. W.]

Throat, Diseases of.—The various throat affections to which farm live stock are liable are fully described in the arts. LARYNGITIS; CATARRH; ROARING AND WHISTLING; HOOSE; TUBERCULOSIS.

Thrombosis.—A clot of blood in a vessel, more often a vein than an artery, is known as a thrombus, and the condition as thrombosis, when it more or less completely obstructs the canal. It follows upon accidents and injuries where coagulation results, and the clot is carried into a vessel and arrested by a valve or by reaching one in which its further passage is impeded by the smallness of the channel. Clots following on parturition are perhaps the most frequent, and give rise to lameness behind, through plugging of a vessel of supply to the limb. A clot from an injured ear has been known to cause plugging in the lungs, and thrombosis and pneumonia. Thrombi are not often within the range of treatment, but there is a tendency to fatty degeneration and gradual absorption, with restoration of function as the obstruction disappears. [H L.]

Thrush is the name given to a discharge from the cleft of the frog of the horse's foot, often extending to its whole substance. It consists of degenerate horny material and has a very obnoxious odour. It is caused by imperfect secretion of the horn papillæ, and is seldom seen in unshod horses with frogs, which have their share in bearing the animal's weight and are consequently functionally active. The raising of the frog from the ground by a rim of iron attached to the crust is a physiological crime, but an economic necessity. It throws the frog out of work; atrophy and degeneration follows, and then the falling-in of the heels, or so-called contracted feet. 'Wired in' is the term given by farriers. The true remedy is to restore frog pressure. With the carriage horse this is done by a variety of rubber and leather pads. Blacksmiths should be instructed to remove no part of the frog or sole save ragged

or exfoliating portions. Provided the shoes of the general-utility horse are not 'growing in'—pressing on the seat of corn—he derives benefit from wearing them until they become thin and permit the frog to come more in contact with the ground. The hunter and the farm horse get some assistance from going over the soil. Standing in stale litter on bad floors doubtless contributes to causing thrush. Calomel dusted into the fissures, or a nightly dressing of 5 parts Stockholm tar to 1 of table salt, is curative, as are all metallic salts in solution, but they dry up the foot instead of restoring the function of the frog; and it is to the measures above advocated we would specially call attention. [H. L.]

Thuja, a genus (including Biota and Thujopsis) which comprises about a dozen species of very ornamental, hardy conifers, the foliage of some of which changes to brown in winter, becoming green again in spring. The leaves and cones are small. The most valuable species for planting are: *T. dolabrata*, Japan, which forms a large tree, and has shining leaves. There is a variety *variegata* marked with creamy yellow, and another of dwarf habit (*nana*). *T. gigantea*, Rocky Mountains, a handsome fast-growing tree, somewhat fastigiate in habit, and well adapted for avenue planting, or to form a screen. It attains to 150 ft. in height, and there are several varieties. *T. japonica*, Japan, an ornamental shrub of erect conical habit. *T. occidentalis*, American Arbor-vitæ, White Cedar, height 40 ft. to 50 ft.; introduced from North America in 1598. There are several varieties, including a Siberian form. *T. orientalis* (*Biota orientalis*), Chinese Arbor-vitæ, a low tree or pyramidal bush which is very variable. It is one of the best ornamental shrubs; *aurea*, *japonica*, *compacta*, *elegantissima*, *meldensis*, *pendula*, and *semperaurescens* are all good forms. The species of Thuja are raised from seeds sown in spring under glass. Cuttings of half-ripened shoots taken in summer readily root in heat or in a shaded frame. The forms are commonly grafted on seedling stocks. These trees thrive in almost any soil, but it should not be very wet or poor in quality. [W. W.]

Thyme.—Two species of Thymus (nat. ord. Labiatæ) are cultivated in gardens for their aromatic leaves, which are used in soups and stuffings. These are Common Thyme (*T. vulgaris*), of which there are narrow- and broad-leaved varieties; and Lemon Thyme (*T. serpyllum* or *Citriodorus vulgaris*), which has a creeping habit. Thyme is usually grown as an edging plant, for which purpose it should be replanted every three or four years. Plants are generally raised from seeds sown in April in finely prepared soil, either where they are to stand or in a seedbed, being eventually transplanted to from 4 to 6 in. apart. Thyme is also readily increased by division in March or April, this being the best method with Lemon Thyme; or by cutting or layering. A light, rich, well-drained soil and warm position are best for the plants. The branches are cut just before coming into flower, and hung up in an airy place for use when required. [W. W.]

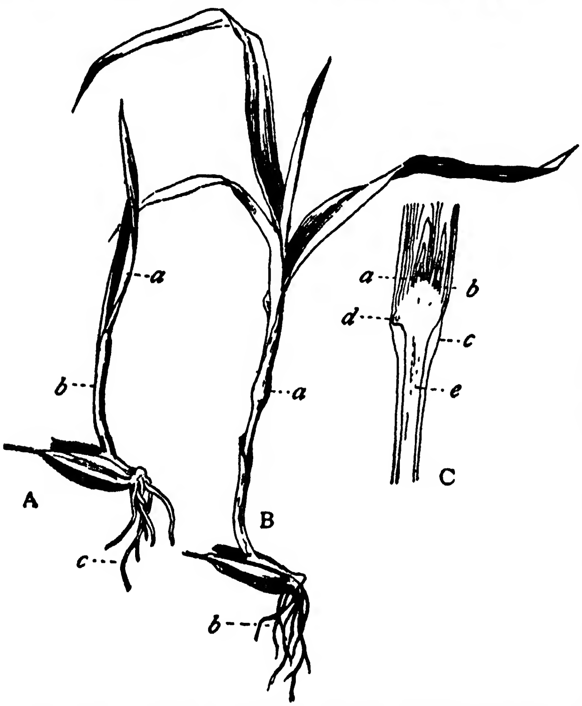
Ticks.—These acarina have been long known, the dog tick being mentioned by Aristotle. Recent investigations have established the fact that quite a number of diseases are tick-borne. Redwater and Texas fever, whether varieties of the same disease or not, have been traced to inoculation by ticks which have themselves been infected. The males and the nymphs feed upon pus or other products of the inflammation they cause by biting, but the females suck blood and in the act infect their hosts. The disease is carried to the next generation although they have not had contact with an infected animal. The reader is referred to the arts. TEXAS FEVER and REDWATER. The means of eradicating them from infested pastures is dealt with under TEXAS FEVER and REDWATER. See also IXODES. [H. L.]

Tiger Moth, a brilliantly coloured moth whose larvæ cause much destruction on garden plants and moths. See ARCTIA.

Tillage.—Under the expression 'tillage' (which Johnson defines as 'husbandry') a large number of operations might be included. It is difficult to separate current acts of tillage from drainage, subsoiling, or clay-burning, as all of them improve the physical, or mechanical, condition of the soil. The term is, however, commonly restricted to operations which take place in the ordinary course of crop cultivation; but 'tillages', as understood by valuers, is more elastic, and may include processes which are not performed by implements. A schedule of tillages might, for instance, contain an allowance for the consumption of a root crop upon the land by sheep; a dressing of dung, or of artificial manure, or the residual value of clover or sainfoin root, left for the benefit of an incoming tenant. There are other operations, which, although of similar nature, appear under other headings, such as liming, chalking, marling, and boning. These may or may not have been immediately applied to a recent or standing crop, and are more conveniently scheduled under 'compensation' for unexhausted improvements, or it may be for cake and purchased foods consumed on the holding.

Tillage may therefore be regarded from two points of view. First, as a general term for acts of husbandry such as ploughing, harrowing, and rolling; and, secondly, as including every process which fits the ground for producing better crops. In this latter sense tillage may properly be considered as 'husbandry', but, as understood by valuers, it is restricted to operations preceding a particular crop. Tillages, as an asset of a sitting tenant, are usually barred by the realization of the crop to which they are applied. Thus no tillages are allowed on a corn stubble, or after potatoes, or after any crop sold off the land. There are, however, half-tillages, as when a root crop has been consumed and the residual benefits still remain; and these half-tillages are recognized by all valuers as constituting valid claims. Tillages, however, generally refer to the current expenditure of the year; and back-tillages, of a durable character, are more properly classed under the head of compensation. [J. Wr.]

Tillering is the term applied by agriculturists to the process of branching whereby many leafy shoots are produced from a single grass 'seed'. At first, when the 'seed' germinates, there is but one shoot derived from the plumule bud of the embryo plant. Later, new buds are produced in the axils of the ground leaves of this first shoot, and these grow up, becoming additional shoots. The new shoots repeat the process, and so a tuft of many ground shoots is formed from a single 'seed'. In the case of cereals, the seeds are sown so thickly that the plants have little chance of displaying their tillering powers. However, if the circumstances are such that the plants stand thin on the ground, then the tillering power is more in evidence. New shoots are produced, and the ground becomes more thickly covered. In pasture formation, the tillering process is of prime importance, for on it depends the production of a tuft of grass, the formation of a close sward, the renewal of the grass as the shoots are eaten down, and the gradual filling up with the perennial grasses as the shortlived grasses die out (see GRASSES). [A. N. M'A.]



A, Young Barley Plant, showing—*a*, Blade of first green leaf; *b*, first sheathing leaf; *c*, seminal roots. B, Young barley plant at later stage than A, showing—*a*, first node; *b*, seminal roots. C, Longitudinal section of B, at *a*. *a*, Terminal bud; *b*, lateral bud (first tiller); *c*, sheathing leaf; *d*, adventitious root forming; *e*, Stem.

Tilletia, the botanical name of a genus of Smut-fungi or Ustilagineæ. The species commonest in Britain is *Tilletia tritici*, the Bunt or Stinking Smut of wheat, but other species are recorded as injurious to maize, barley, rice, other grasses, and sedges The presence of much *Tilletia* smut renders fodder and grain unpalatable to animals, and poisoning is said to result from continued consumption. The spores of *Tilletia* are generally larger than those of the nearly allied *Ustilago*, but they are easily distinguished if germinated in water (see fig. 10, art. FUNGI). There may be considerable variation in the germination, but the usual course is that a short erect germ-tube is formed bearing a crown of six to twelve long slender sporidia (basidiospores). Some of these become connected in pairs by a cross-filament (like the crossbar of the letter H), and from this arise smaller secondary sporidia each capable of conveying infection. The prevention and treatment of Bunt will be found in art. WHEAT—PARASITIC FUNGI. [W. G. S.]

Tilth.—The crumbly condition of the soil necessary to secure a good tilth is the result of having the clay, the organic matter, and the calcium carbonate in their best condition. The clay must be in a proper flocculated state, brought about by the presence of calcium carbonate and organic matter; the organic matter must be thoroughly distributed all over the soil, and must be sufficiently decomposed. Soil organisms, therefore, play an important part—indeed some writers ascribe to them the chief part. The calcium carbonate must also be uniformly distributed. It is obviously necessary, before producing a tilth, to break down the clods either by tillage implements or, better, by frost. The last stages in the process require considerable judgment: if the soil is too dry the labour is simply wasted, if it is too wet the tilth may be spoiled. Tilth is so difficult to obtain on very stiff soils in our wet climate that they have commonly gone out of cultivation. The commonest and most certain way of spoiling tilth is to deflocculate the clay. This is done by working the soil when wet, bringing up unkindly subsoil from below, and, on stiff soils, using manures like liquid manure or nitrate of soda, that leave alkaline residues in the soil. On the other hand, tilth is not injured by acid manures like superphosphate or ammonium sulphate, and is improved by adding lime, basic slag, or organic matter like dung, ploughing in green crops, or, in suitable cases, feeding crops on the land. [E. J. R.]

Timber.—The technical properties of timber depend mainly on its anatomical structure and its chemical composition, and are evidenced in its outward appearance, its material condition, and its relation towards external influences.

1. *As regards Anatomical Structure*, the woody parts of trees consist of: (1) woody fibres, (2) wood-vessels, and (3) wood-cells (except in some conifers). (1) The woody fibres are elongated, pointed at both ends, and thick-walled; and they are formed of hard tissue (sclerenchyma) with walls dotted with small pits, and of tubes

(tracheids) with large internal spaces (lumina), whose walls are dotted with large bordered pits; and sometimes there is also a subordinate form of wood fibre shaped like true hard tissue, but filled with protoplasm, starch, and other substances. (2) The wood-vessels, seen as pores on making a transverse section, are long narrow tubes closed at both ends, with thin walls and large lumina. (3) The wood-cells forming soft tissue (parenchyma) are thin-walled, more or less cubical, and mostly with flattened ends; and they are chiefly found near the vessels, where they store reserve nutrients (starch, &c.) for reproductive purposes (new foliage, flowers, and fruit, &c.), while the sap is conveyed through the woody fibres and the vessels.

The wood of broad-leaved trees contains all three kinds of woody fibres, while that of conifers consists only of tracheid fibres. Hence, the larger the relative proportion of hard tissue, the heavier, harder, and stronger is the wood of any given kind of broad-leaved tree; and the larger the proportion of thick-walled tracheids with small lumina produced during the warm summer weather, as compared with the thin-walled tracheids with large lumina forming the softer inner zone produced in spring, the heavier, harder, and stronger is the wood of any given kind of coniferous tree. In conifers, any wood-cells formed are found only around the resin-ducts in the Abietineæ, and are sparsely scattered throughout the tracheids in the other kinds. But both broad-leaved and coniferous trees have medullary rays, formed of wood-cells, extending radially from the central pith (or some annual ring near it) to the bark. These medullary rays serve partly for storing reserve nutrients in winter (for leaf production, &c., in spring), and their number and size affect the technical properties of timber. In conifers they are narrow and close, giving a sort of silky gloss to a thin transverse section; but in broad-leaved trees they are usually more prominent, being largest of all in Oak, where they form the 'flowering' when planks are cut radially to show 'the silver side'. These rays are broadest in Oak and Beech, and highest in Oak and Alder; fairly broad in Ash, Elm, Maple, Sycamore, Plane, and Hornbeam; narrow in Alder, Birch, Cherry, Chestnut, Horse-chestnut, Lime, and Robinia; and almost indistinguishable in Willows and Poplars. The wood of conifers differs further from that of broad-leaved trees by usually having resin-ducts or tubular spaces surrounded by resin-producing cells without definitely constructed walls. These resin-ducts are not only found running longitudinally in the stem and branches, usually in the summer zone of wood, but also occur along the medullary rays. Both of these two kinds of resin-ducts communicate with each other, and the total quantity of resin stored up in the wood has a great influence on its technical properties.

The width of each annual ring of wood varies with the soil and situation, and the amount and intensity of light during the growing period; and the annual rings are usually broader in young and middle-aged than in old trees, while they are always broadest near the butt of the stem; but the best class of timber is that in which the breadth of the successive annual rings is fairly equal, and where the annual rings have a relatively broad dense zone of summer wood formed during the warmest time of the year.

2. *As regards Chemical Composition*, green wood consists usually of about 50 to 75 per cent of woody substance, and 25 to 50 per cent of sap or water containing organic and mineral substances in solution and suspension; and even after being seasoned or air-dried, from 10 to 12 per cent of its weight consists of water. The framework of the woody fibres, vessels, and cells is cellulose ($C_6H_{10}O_5$), with a composition of about 44 carbon, 6 hydrogen, and 50 oxygen per cent, which during a process called *lignification* loses oxygen and absorbs more carbon along with nitrogen and mineral substances. But the elementary composition of the dry woody substance varies only slightly in different woods, the rough average consisting of the following percentages: 50 carbon, 6 hydrogen, 42 oxygen, 1 nitrogen, and 1 ash or incombustible mineral substances consisting chiefly of lime, potash, magnesia, and phosphoric acid, the amount and composition of which vary, of course, according to the kind of tree and the soil, situation, and climate. The organic and mineral substances in solution or suspension in the sap are parts of the cell-wall or products of its transformation, and include protein or nitrogenous matter, carbohydrates, and glucosides; oils, resins, and aromatic substances; tannic, oxalic, and other acids; and dyestuffs; and these combine to give the different parts of the tree, and especially the heartwood, their own peculiar and distinctive colour, aroma, and properties. Some trees form a harder and darker-coloured heartwood of inert tissue, which is heavier, more thickly stored with organic and mineral substances, and more durable than the younger zone of sapwood, in which sap can still ascend (see HEARTWOOD and SAPWOOD).

3. *The Ornamental Properties of Timber* are its colour, lustre, grain, texture, and marking, and sometimes also its odour or aroma (*e.g.* Camphor-wood). When green or freshly sawn, timber is lighter in colour than when seasoned and long exposed to the air. Woods used for ornamental purposes, such as furniture, wainscoting, &c., are chiefly selected on account of their colour, texture, and marking; and the coarser the grain of the wood, the more the texture and the marking are displayed (as in Ash and Mahogany); while the greatest variety of marking is shown on a radial section fully exposing the medullary rays (*e.g.* the 'flowering' of Oak). Forked growth and abnormal 'burr' excrescences increase the value of timber for ornamental purposes, though depreciating its value for building and construction. There is, however, a fashion in woods; and many beautiful tropical and subtropical kinds of timber can only be sold profitably in Britain under some fictitious name like 'Australian Teak' or 'Canadian Mahogany', suggestive of well-known woods long in demand, and to which they bear some resemblance.

4. *The Physical Properties of Timber*, upon which its mechanical properties are directly dependent,

and which are therefore of far more importance than mere outward appearance, are: (1) its density and weight, (2) the amount of water it contains, or the extent to which it is seasoned, (3) its relation towards drought and moisture, as evidenced in shrinking, cracking or splitting, warping, and expanding, and (4) its freedom from defects and unsoundness. All these physical properties are continually acting and reacting on each other; for the dryness or moistness of the wood affects its density or specific weight as well as its total volume, and also the direction in which shrinkage and expansion take place under dry and moist conditions of the atmosphere.

(1) *As regards density and weight*, the specific weight of the pure woody substance (exclusive of lumina and other hollow spaces) is in our woodland trees on the average about 1·5 both for heartwood and sapwood; but the specific gravity per cubic foot of wood varies greatly for different kinds of trees; while for any given kind it also varies greatly in the green and the seasoned conditions. For technical purposes it is only the seasoned weight that is important, as green timber is not used. Oak, Ash, Beech, Hornbeam, Maple, Elm, and Robinia are heavy woods (sp. gr. 0·7 and above); Sycamore, Chestnut, Plane, Birch, and Larch are of moderate weight (0·6 to 0·7); while Horse-chestnut, Alder, Douglas Fir, Pine, Spruce, Silver Fir, Willow, Poplar, Lime, *Thuja gigantea*, and most other conifers are light (0·4 to 0·6).

(2) *As regards moistness or dryness*, green timber on the average contains sap or water to about one-half of its total weight (42 per cent in hardwoods, 52 in softwoods, and 57 in conifers); and it still retains water to about 10 per cent of its weight when thoroughly seasoned (8 to 10 in broad-leaved, and 10 to 12 in conifer wood, or more if very resinous). To save time and money the more valuable kinds of furniture woods are now usually dried in hot-air chambers, as this does not affect their strength; otherwise seasoning takes two to four years for barked logs, and splitting and warping are likely to occur if logs are sawn into planks before seasoning.

(3) *As regards relation to water*, upon which shrinking, cracking, splitting, warping, and expansion depend, wood shrinks more or less in seasoning and thus tends to warp, the dense, slow-drying heartwood shrinking more gradually than sapwood, and resinous conifer wood more gradually than that of broad-leaved trees. But the specific weight of wood gives no indication of its liability to shrink or warp. Lime, Beech, Hornbeam, Elm, Chestnut, Birch, and Alder shrink most, and pedunculate Oak and conifers least. Shrinkage is least longitudinally, greater radially (about 6 per cent), and greatest tangentially (about 10 per cent); and it is this want of uniformity in the rate of shrinkage that occasions warping, cracking, and splitting. The more rapid the shrinkage, the greater the tendency to warp, crack, and split; hence summer-felled timber is more likely than winter-felled to do so, and barked logs crack and split more than those left with bark on (which in conifers would lead to bark beetles breeding in large numbers). Practically, in proportion as wood shrinks in seasoning, it swells or expands again by absorbing water in a damp state of the air; and this must be allowed for in construction with timber.

(4) *Defects in timber* are due to abnormal anatomic structure and other conditions, and include branch knots, twisted fibre, wound-surfaces and rind-galls completely covered, and shakes of various kinds (simple or star-shaped heart-shakes, frost cracks, cup- or ring-shakes), which all depreciate the value of timber for technical purposes.

(5) *Unsoundness* is due to fungus disease. The chief kinds of unsoundness are canker, red-rot, white-rot, white-piping (Oak), and blueing of conifers (especially Scots Pine); but root-rot, branch-rot, and stem-rot are common in old trees growing on unsuitable or imperfectly drained land. And even after it is converted and used in construction, timber, especially if only partially seasoned or in a damp place, is liable to be attacked by dry-rot (due to *Merulius lacrymans*) and other saprophytic fungi.

5. *The Mechanical Properties of Timber* are of the first importance, as they govern its relation to external influences. They include strength, elasticity, flexibility, toughness, fissibility, hardness, and durability.

(1) *Strength* in timber is the resistance offered to any force tending to separate its fibres, whether applied longitudinally as if pulling the fibres apart (*tension*), or pressing them together (*crushing*), or at right angles to the grain (*transverse pressure or breaking-strain*), or so as to twist the fibres (*torsion*), or more or less parallel to the grain so as to displace and separate the fibres sideways (*shearing*). The *breaking-strain* is by far the most important in timber used for construction. Of our British woods, Oak, Ash, and Larch stand this pressure best; then other hardwoods; and sapwoods and very resinous conifer timber least (though Spruce better than Silver Fir, and Silver Fir better than Scots Pine); but any defect or unsoundness weakens the strength. The coefficient of transverse strength can be obtained from the formula—

$$P = \frac{W \times L}{B \times D^2},$$

where W is the weight in pounds placed on middle of the bar which causes it to break; L the length of bar in feet, between supports; B the breadth and D the depth in inches.

(2) *Elasticity, Flexibility, and Toughness.*—In timber, elasticity is proportionate to the strength; while flexibility and toughness usually increase with the amount of water, and are greater in green than in partly or wholly seasoned wood, and also much increased by steaming. Hardwoods have generally the greatest elasticity, and softwoods the greatest flexibility and toughness; while in conifers a moderate amount of resin increases, and much resin diminishes them; but all these three properties depend on the length and straightness of the woody fibres, and are diminished by branch-knots and ab-

normal growth of any kind. The modulus of elasticity is found from the formula—

$$E = \frac{L^3}{B \times D^3} \times \frac{W}{d},$$

where L, B, and D are as above, and W is the weight in pounds supported at the centre of the bar and causing a deflection of d inches.

(3) *Fissibility* is the ease with which wood can be split by a wedge driven in parallel to the run of its fibres. Alder, Lime, and conifers (unless very resinous) are easiest to split, and Hornbeam, Elm, Willow, Poplar, Birch, Maple, and Sycamore hardest; while Oak, Ash, Beech, Chestnut, &c., occupy an intermediate position. Fissibility is greatest in long and straight-fibred woods, and least where fibres are short and strongly lignified; and the drier and more elastic the wood, the easier it is to split (except Willow, Poplar, and Alder, in which the wedge holds better when the wood is moist). The greater the fissibility, the more difficult it is to obtain a fine smooth surface by planing.

(4) *Hardness* is the resistance offered to the penetration of another body, and is usually characteristic of heavy woods, the hardness increasing with the strength and cohesiveness of the woody fibres (see HARDWOODS and SOFTWOODS).

(5) *Durability* means the length of time timber continues sound and serviceable; and this, of course, varies greatly according to how and where it is used. It depends mainly, however, on the extent to which the wood is exposed to alternating dampness and dryness, especially during the warmer months of the year; for it is then that the various timber-boring insects (Anobium, Ptilinus, Lymexylon, &c.) and the many saprophytic fungi (Polyporus, Agaricus, Merulius, &c.), which are chiefly instrumental in decomposing the woody tissues and the ligneous substances, find the most favourable conditions for their thriving and development. The mere weight of wood gives no proper indication of its durability; because the larger the quantity of albuminoid substances contained in any kind of wood, the more likely it is to be attacked by fungi and insects which feed on these; but, for one and the same kind of wood (whether Oak, Beech, Larch, Pine, &c.), the heavier it is, the more durable, owing to the higher proportion of lignin and preservative substances per unit of volume. As regards general durability, Oak and other hardwoods (except Beech) are usually much more durable than softwoods, and Larch lasts longer than Pines or Firs; but in conifers it increases with resinousness. Seasoning increases durability, and winter-felled timber is more durable than summer-felled. The durability can be greatly increased by artificial means (see also TIMBER PRESERVATION and DURABILITY OF MATERIALS). [J. N.]

Timber- and Tree-destroying Fungi.—Unsound timber is evidence that the tree has grown abnormally. It may be that because of weakness it was unable to produce sound timber, or that because of some unfavourable condition in the soil or atmospheric environment, the tree was imperfectly nourished. As growth depends on the activity of the leaves, it follows that any extensive injury to the foliage by insects or other animals will also result in some unsoundness in the timber. The fungi are another important group of injurious agents which do much damage both in the forest and afterwards when the timber is in use.

Almost all the fungi which destroy timber can live as saprophytes on dead wood or on dead parts of a tree. So long as the tree retains its natural bark, these fungi are unable to reach the living tissues, and it is only after the bark is broken that an entrance is effected. Wounds suitable for the entrance of destructive fungi are produced by wind and frost, by insects and other animals (*e.g.* squirrels and rabbits), and during the operations of thinning, pruning, felling, and timber-hauling. Through wounds the fungus filaments reach the living tissues, and as they have the power of secreting enzymes capable of dissolving cellulose, lignin, starch, and other nutritive materials in the wood, they convert these into food material. The mycelium gradually extends through the tree, frequently between the bark and wood and thence into the medullary rays and other parts of the timber; filaments of the mycelium may also bore through the walls of the wood-cells, and gradually corrode the lignified walls (see fig. 2, art. FUNGI). In this way the walls are either reduced to the thinnest of membranes or the wood becomes a fine powder; in both cases decaying cavities are produced. If the mycelium attacks the cambium or other living tissues, these are frequently stimulated to abnormal growth and 'cankers' are produced, with swelling and distortion of the stem, and often with exudation of gum or resin.

Fig. 1.—Stem of Oak destroyed by Fungi, which first attacked the Branch Snag

The recognition of the particular fungus in any case is the work of the specialist with wide experience, but a brief description of some of the more prevalent timber-destroying fungi may assist identification. It will be best to arrange them in their respective groups used in the classification in art. FUNGI.

Order *Ascomycetes*: (1) *Nectria*.—Three species are destructive to trees, and all are wound-fungi commencing their existence on broken branches or wounds, whence they spread into living parts. The sporules are produced in little red cushions on the bark.

Nectria ditissima is a frequent cause of canker on Apple, Ash, and other trees (see APPLE—PARASITIC FUNGI, with illustration).

N. cinnabarina occurs on dead branches of many deciduous trees, and the bright-red sporule-cushions are familiar enough.

N. cucurbitula frequents conifers, and re-

sembles the last-named species except that the cushions are dark-red.

(2) *Pesiza*: *P. willkommii*, the Larch canker (see LARCH DISEASE).

Order *Basidiomycetes*.—(*a*) Mushroom fungi (*Agaricus*), with gills on the sporophores (see fig. 7, art. FUNGI).

Agaricus melleus, the honey fungus; a destructive root-fungus, most frequent on conifers, but also occurring on hardwoods and on felled timber. The bark at the base of the tree dies, sometimes forming a resinous canker, and a white sheet of mycelium is present between bark and wood. The sporophores are yellowish mushrooms with dark scales; they are produced round the tree on roots or soil, and are nourished from the white absorbing mycelium by means of black cords (rhizomorphs) which run below the bark.

(*b*) Polypore Fungi.—This numerous and destructive group is distinguished from the Agarics by the shape of the sporophore, which is rarely mushroom-like; numerous pores containing the spores give the group its name. The remaining fungi in this list all belong to the Polypores; besides the chief genus *Polyporus* there are others (*Trametes*, &c.) which differ in the structure of the sporophore.

Polyporus fomentarius, the tinder-fungus of Beech and other trees. The sporophores are bracket-like, frequently large in size, and are perennial, continuing to grow for several years (see fig., art. BEECH—PARASITIC FUNGI). This produces a white rot in the timber.

P. betulinus, very common on Birch; the white sporophores adhering to the bark are conspicuous; they are annual, growing and decaying in a single season.

P. sulphureus, a common parasite on Oak, Chestnut, Poplar, &c. The annual sporophores are flat and soft, orange-red on the upper surface, sulphur-yellow below. It produces a red rot with cavities filled in with white felted mycelium, and the timber becomes dry and brittle.

P. igniarius, common on deciduous trees generally. The perennial sporophores are hoof-shaped, the upper surface being greyish-brown and hard like stone. It produces a white rot.

P. dryadeus, a common species on Oak, with large annual bracket-shaped sporophores, generally near the base of the tree; at first they are soft, but later become chocolate-coloured and brittle. The timber shows white or yellowish stripes surrounded by firm wood little changed from its natural colour.

P. squamosus, the scaly polypore, with annual sporophores which are thin and flat, the upper surface being yellow with brown scales.

P. hispidus, on Ash, and on Apple and other fruit trees, has thick annual sporophores with a rough velvety upper surface (see ASH—FUNGOID DISEASES).

P. vaporarius is common on Pine and Spruce, and in structural timber does much damage through causing a rot very like true dry rot. The sporophores are not bracket-like, but form closely clinging crusts.

Merulius lachrymans, the dry-rot fungus (see art. DRY ROT OF TIMBER).

Trametes radiciperda, a destructive root parasite, especially on conifers. It produces a red rot speckled with white spots with blackish centres (fig. 2). The sporophores form crusts on the bark.

Trametes pini attacks the stem generally near a broken branch; it occurs mostly in Pine, and as the mycelium extends along certain year-rings the wood tends to split in concentric plates, hence the popular name 'ring-scale' or 'ring-shake'. The hard brown sporophores adhere closely to the bark, sometimes forming a hoof-like mass.

Stereum hirsutum occurs on dead wood and structural timber, but is parasitic on Oak, producing a red rot marked with whitish streaks.

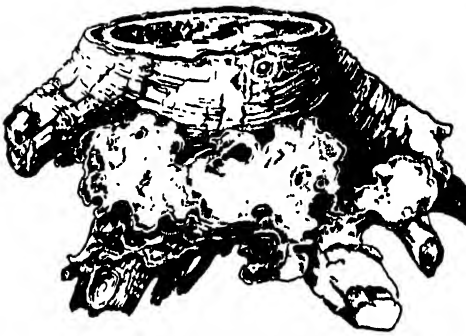


Fig 2.—*Trametes radiciperda* growing on Stool of Spruce (after Tubeuf)

The sporophores are crusted, or hang from the bark as leathery yellowish flaps with hairy margins.

Fistulina hepatica, with sporophores like flaps of fresh liver hanging from Oak—hence the popular name 'beef-steak fungus'; the mycelium produces a deep-brown rot in the wood.

Dædalea quercina is abundant on Oak stumps, but is a doubtful parasite (see fig. 8, art. FUNGI).

While the majority of these fungi are most active in the growing tree, a certain number may find their way into structural timber and cause much damage. This may be prevented by careful selection of sound timber, and thorough seasoning; the precautions to be followed in buildings are given in art. DRY ROT OF TIMBER.

Treatment.—In woods and plantations all dead wood should be cleared out or burnt, because it is a nursery for these timber-destroying fungi. Another thing to remember is that almost all these fungi are wound-parasites; and although broken branches cannot be avoided, yet much may be done to prevent unnecessary damage during thinning and felling; by carelessness much damage may be done, especially when logs are hauled recklessly so as to bruise standing trees and thus prepare the way for destructive fungi. Trees showing sporophores or otherwise unsound should be selected first in thinning. In the case of parks where owners object to the removal of trees, much may be done by early attention to broken branches; they should be carefully pruned and the cut surfaces dressed with tar. It is very doubtful whether covering

decayed wounds with metal, cement, &c., is of much benefit, because the fungi generally remain quite active; a filling of cement might be effective if the cavity were cleaned out, then charred, and dressed with tar before filling up.
[W. G. S.]

Timber, Preservation of.—The larger the proportion of nitrogenous or albuminoid substances contained in any kind of wood, the more likely it is to be attacked by insects and saprophytic fungi. These are the chief causes of decay, and their attacks are facilitated when timber is exposed to rapid alternation of dampness and dryness, especially if combined with warmth. If the albumen can be sterilized or so altered as to be made unfit for the food of insects and fungi, the woody fibres then become strongly protected against both of these destructive agencies, and also against the action, thus obviated, of dissolving ferments developing under their operation. Some kinds of timber, and notably hardwoods as compared with softwoods, and very resinous as compared with only slightly resinous conifers, have more or less of natural protection from substances contained in their tissue, *e.g.* the tannic acid in Oak, essential oils distasteful to insects in Teak, Camphor-wood, and Deodar, strong resinification in Larch and Pine, &c.; but all timber is much more durable if utilized in dry and airy places, or else entirely submerged in water or buried in the ground, where atmospheric oxygen is cut off and there are practically no alternating changes from wet to dry. The weight of a piece of wood gives of itself no reliable indication of its durability, *e.g.* Beech used, say, for fencing decays much sooner than Larch; but for any one particular kind of wood (Oak, Ash, Beech, Larch, Pine, Spruce, &c.), the higher the specific gravity the more durable the timber, because that means a larger proportion of woody fibres, and of lignin, tannic acid, resin, and other substances preservative of the woody tissue. Speaking generally, wood felled in autumn, just about the fall of the leaf, when there is least sap in the tree, is more durable than that cut at any other time of the year; and wood felled just before the flush of the foliage in spring, when the tree is fullest of sap, is usually least durable.

The preservation of timber may take place—

1. *By seasoning*—
   (1) Naturally, by gradual drying in the open air.
   (2) Artificially, by evaporating the sap in hot-air chambers.
2. *By impregnation with antiseptic substances*—
   (1) Through simple immersion.
   (2) Through injection under pressure.

Seasoning, whether by slow natural process or by artificial means, renders wood much lighter in weight and more durable. Mere superficial coating with paint, &c., is of little use unless the wood is thoroughly seasoned and is to be used indoors. But by far the most effective way of increasing durability is to impregnate the woody tissue as thoroughly as possible with antiseptic fluids, rendering the albuminoid substances unfit for the food of insects and fungi (see also DURABILITY OF MATERIALS).

The earliest methods of preservation by antiseptic means were simple submersion of converted wood in sea-water, or in a solution of common salt, or in milk of lime (a 1-in-40 solution of slaked lime in water), or by charring and coal-tarring fence-posts and stobs at the lower ends put near or below the surface of the ground. The ideal preservative fluid would be one that preserves thoroughly, penetrates easily and deeply into the wood, remains there permanently, is cheap and innocuous, and does not increase the inflammability of the wood; but no such impregnating substance has yet been discovered. For large timber the four oldest antiseptic processes worked on any large scale are: (1) *Kyan's method* (1832), by simple immersion and imbibition of a 1-per-cent solution of bichloride of mercury, 1 lb. dissolved in 10 gal. of water (100 lb.) being sufficient to impregnate 50 cu. ft. of well-seasoned timber; (2) *Burnett's method* (1838), by injecting a 2- to 3-per-cent chloride of zinc solution under pneumatic pressure of 105 lb. per square inch ($7\frac{1}{2}$ atmospheres) at 230° F., the wood operated on (chiefly for railway sleepers) being thoroughly seasoned; (3) *Bethell's method* (1838), by injecting creosote or crude heavy oil of coal-tar into thoroughly seasoned wood under a pressure of 140 lb. per square inch and at a temperature of 120° F.; and (4) *Boucherie's method* (1840), by injecting a 1-per-cent solution of sulphate of copper (blue vitriol) under a pressure of 14 to 28 lb. per square inch by means of a gutta-percha tube conveying the solution from a tank 30 to 33 ft. overhead into a narrow chamber formed by a cap fitting over one end of the log, so as to force out the sap from the other free end as the solution presses its way in, a process which is easier in the case of green than of seasoned wood.

The *corrosive sublimate* method preserves well, but is dear and poisonous, corroding iron and causing sores on workmen's hands, and soon dissolving out in wet places. *Chloride of zinc* is a weak antiseptic, and is easily soluble, but soon gets washed out. *Creosote* is nearly as strong an antiseptic as corrosive sublimate, and is not poisonous; but it is dear, pungent in odour, and greatly increases the inflammability of wood treated; it is therefore only suitable for timber used in the open air, and not for house-building timber and pitwood. *Sulphate of copper* is a weak antiseptic and corrodes iron, but is the cheapest process. Impregnating with creosote, originally introduced by Bethell in 1838 with pneumatic pressure, is the chief British method.

Creosoting with heavy coal-tar oil (boiling-point 365° F.) may either take place by simple immersion in open iron tanks, or by injection under pressure in closed iron cylinders. The simplest and cheapest way to treat small quantities of well-seasoned wood (such as fence-posts, &c.) by immersion is to pack it (after being warmed, if convenient) into the open tank, and fill this with creosote and heat it to a little over 212° F. (to evaporate the water still in the wood); then keep it at that heat for about twenty-four hours (or more, according to size of wood), run off the hot oil, and take out the creosoted wood

when cool enough to handle. For such purposes, an open oblong iron tank or boiler and a furnace cost about £60. Beech and Scots Pine absorb the oil most readily, and Spruce and Larch least readily; while softwoods and conifers generally absorb more readily than hardwoods. Scots Pine and softwoods take easily about 8 to 9 lb. and even up to 10 to 11 lb. (1 gal.) of creosote per square foot; but Oak and Larch, the most durable woods without treatment, do not absorb the oil well. Creosoted Beech fence-stobs last twenty years, while untreated Beech only lasts about three years. In the case of Scots Pine stobs, long immersion is a waste of creosote, as it runs out again on the stobs being stacked after treatment. As absorption is not uniform, the cost of creosoting varies both with the kind and the quality of the wood; but with creosote at $2\frac{3}{4}d.$ a gal., creosoting usually comes to nearly $4d.$ per cubic foot, or $1d.$ per fence-stob $4\frac{1}{2}$ ft. × 3 in. × 3 in., and $9d.$ per 100 lineal feet of paling rails 4 × 1 in. (though ranging up to $6d.$ and $1s.\ 3d.$ respectively).

When creosoting large quantities of wood, railway sleepers, &c., in closed iron cylinders with injection under pressure, the timber is packed as closely as possible, the air extracted by an air-pump, and creosote heated to 120° F. run in; and when full, a force-pump is used to gradually produce whatever pressure is desired (usually 100 to 120 lb., but sometimes more), until a gauge attached to the creosote tank shows that absorption has ceased. Softwoods can thus be made to absorb 10 to 12 lb. of oil per cubic foot. At Welbeck a pressure-cylinder 30 ft. long by $4\frac{3}{4}$ ft. diameter with self-contained pumps, which cost about £300 and is worked by a $2\frac{1}{2}$ horse-power portable engine, takes a charge of 450 cu. ft. of small converted timber (gates, fence-posts, &c.) that can be subjected to a pressure of 100 lb. per square inch in about three hours. On absorption under that pressure ceasing, the door is unscrewed and the superfluous creosote run off, and the timber is taken out next day. When creosoting is done thus on a large scale, the total cost comes to about $3d.$ to $4d.$ a cubic foot, varying of course according to the price of the creosote. On the average, $2\frac{1}{2}$ gal. or $27\frac{1}{2}$ lb. of creosote are considered enough for Scots Pine sleepers 9 ft. × 10 in. × 5 in. = $3\frac{1}{8}$ cu. ft., or $8\frac{1}{4}$ lb. per cu. ft.; while when Oak sleepers are treated the specification varies from 4 to 6 lb.

In the *Rueping creosote process* the wood is first subjected to a pressure of 60 to 65 lb. to compress the air into the interior cells; and on warm creosote being run in, the pressure is increased to 105 to 225 lb. according to size and quality of timber; while under this high pressure creosoting not adhering to the cell-walls is forced out again and run off, thus effecting a saving in creosote, while giving a more thorough impregnation.

Immersion in an open tank containing heated *naphthaline* ($C_{10}H_8$), also a coal-tar product, was introduced by Mr. Aitken, of Falkirk, in 1882, and has recently come into very extensive use for estate purposes (fence-posts and stobs) under an improved method invented by the late Mr. Henry Darroch, also of Falkirk, which makes wood like Birch, Beech, Scots Pine, Spruce, &c., more durable than Oak, Larch, &c., thus giving fencing material that is both cheaper and lasts longer (up to fifteen or twenty years). In *naphthalining*, the crude naphthaline brought in bags is put into an iron tank heated by steam from a boiler about 20 yd. off, the stove for heating the boiler being carefully isolated owing to the inflammability of the naphthaline. The wood to be treated must be thoroughly seasoned; and the drier it is, the better the result. The tank being packed with fence-posts and stobs and then nearly filled with crude naphthaline (which melts at 176° and boils at 422° F.), steam is applied to raise the heat to over the boiling-point of water (212°). After being kept at this for from two to twelve hours, it is allowed to cool down sufficiently for the wood to be taken out; then other wood and more naphthaline are put in, and the process repeated till all the material has been treated. A tank 21 ft. long and 5 ft. diameter costs about £120, and contains a charge of about 2 tons of naphthaline along with the wood; and when the crude naphthaline costs $35s.$ a ton at a near railway station, the impregnation of tank-loads of mixed hard and soft woods averages about $3d.$ per cubic foot. As regards power of absorbing naphthaline, this is greatest in Scots Pine, Beech, Birch, Alder, and Douglas Fir, much less in Ash, Silver Fir, and Oak, and least of all in Spruce, Larch, and Elm. But creosoting is the preferable method, as naphthalining gives the workmen headaches and is altogether more dangerous.

The *Powell saccharization process* is a recent British method for impregnating the woody tissue with molasses, glucose, or sugar. It is said to darken the colour of wood, and to increase its hardness and density without diminishing its tensile strength, flexibility, and toughness, whilst also slightly decreasing its inflammability. The timber is placed on trollies and let down into a large tank (20 × $9\frac{1}{2}$ × 5 ft.) filled with a solution of syrup or sugar, which is rapidly raised to boiling-point (212° F.) by means of steam circulating through pipes, and then allowed to cool down to 70° by passing water through the pipes; and as the timber cools the solution is absorbed. The timber is then stored in drying-chambers at a temperature of 250° to 300°, and gradually allowed to cool. Conifers and Oak absorb 3 to 4, Willow, Ash, Birch, Elm, and Sycamore 5 to 6, Beech $7\frac{1}{4}$, and Poplar $9\frac{1}{2}$ lb. per cubic foot; and Larch and Spruce, so difficult to creosote, are as easily saccharized as Scots Pine. It is also claimed for this process that by the addition of certain chemicals (of which alum is probably one) the timber is rendered non-inflammable and fire-resisting.

Fireproofing of wood is also carried out by means of impregnation with borates, silicates, and ammoniacal and other volatile salts; but, though it can be made non-inflammable, no process has yet been discovered for rendering wood incombustible.

For superficial coating, oil paint can be made non-inflammable by adding phosphate of ammo-

nia and borax in the form of impalpable powders; while asbestos paint and mortar made of plaster and asbestos are also used, and give partial security against fire. Of several processes for fireproofing wood by impregnation under strong pressure (though unfortunately always only to a limited depth), Payne's is one of the best, the wood being first impregnated in a vacuum with a strong sulphate of iron solution, then under pressure injected with a solution of sulphate of lime or some alkaline carbonate to make the iron insoluble.

In France, *electricity* is also used, both to 'senilize' wood rapidly in order to make it more durable, and to fireproof it. Senilizing takes place by impregnating green wood with a 20-per-cent solution of magnesium sulphate warmed to about 90° F., passed in for seven to fourteen hours by an electric current varying from 4 to 6 amperes, and then drying it in the open air; while for fireproofing, ammoniacal salts are used in place of magnesium sulphate. And in another French process of senilizing, a solution of 10 per cent borax and 5 per cent resin-soap is used in place of the 20-per-cent solution of magnesium sulphate. But as yet it is too early to judge of the success of these methods. [J. N.]

Timber Measurement.—There is no generally accepted definition of timber. As distinguished from fuel, it is wood used for any technical purpose. For railway freight it includes 'all descriptions of wood in an unmanufactured or roughly hewn, or roughly sawn state; but not any wood shaped, or prepared or partially prepared'. As distinguished from coppice, with or without standards, it in English law includes all woods and trees not cut in regular rotation; though in the case of Beech woods in southern England cleared and naturally regenerated about once in every ninety to one hundred years, a legal decision held that such timber could be used by the heir-of-entail through local habit and custom, without impeachment for waste—a restriction not applying to timber on Scottish entailed estates. Again, in selling trees, local custom usually classes as timber only what measures not less than 5 or 6 in. in quarter-girth (20 to 24 in. in girth) under bark (see Bark Allowance); or frequently in Scotland to 6 in. in diameter free from bark; while pitwood is measured down to $2\frac{1}{2}$ in. diameter under bark, or 3 in. over bark at the thin end. Tops and branches below the local customary timber dimensions are not paid for (see Lop and Top).

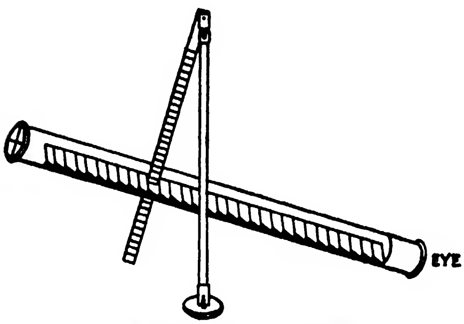
1. *Measurement of Logs or Round Timber.*—After felled trees are cross-cut or definitely marked off into logs, the customary British method of measurement is to multiply the length in feet into the square of the mean quarter-girth in inches taken with tape or string (a steel tape is best) in the middle of the log, and divide by 144 if the quarter-girth is measured in inches, when the cubic contents = length × ($\frac{1}{4}$ mean girth in inches)^2 ÷ 144. Say a log is 20 ft. long and 8 ft. in mean girth; its cubic contents would therefore be reckoned as $20 \times 2^2 = 80$ cubic feet. But these are not the true cubic contents, which are = length × superficies of middle section; or in this case $= 20 \times (8^2 \div 4\pi) = 101.8$ cu. ft. Similarly, a log 18 ft. long and 2 ft. in mean diameter would have true cubic contents of $18 \times 3.14 = 56.52$ cu. ft.; while by square-of-quarter measurement it would be sold and bought as if only containing $18 \times (\frac{1}{4} \times 6.28)^2 = 44.36$ cu. ft. British customary measure thus always reckons only $78\frac{1}{2}$ per cent, or $21\frac{1}{2}$ per cent less than the true cubic contents, the shortage being supposed to represent the loss in sawing up. Ready-reckoning tables show the contents of all sizes of logs. Other British methods of measuring used when specially prescribed are *Customs Measurement* with the divisor 113 (in place of 144), giving the true cubic contents ($144:113 = 100:78\frac{1}{2}$); *Die-square Measure* with the divisor 181, giving the maximum contents when squared; and *Calliper Measure* used in Government dockyards, when the diameter in inches is squared, multiplied into the length in feet, and divided by 181, giving almost exactly the true cubic contents. Railway companies prescribe for square timber the divisor 144; and for round timber the divisor 113 for string-measurement under bark (with right of charging carriage for bark also), and 144 for tape-over-bark. But the railway rules are so complicated that those seeking detailed information should consult the General Railway Classification of Goods last issued. In measuring squared or converted timber the true cubic contents are reckoned by multiplying into each other the length, breadth, and depth. In America, Australia, and New Zealand, *board measurement* obtains, based on the number of superficial feet of 1-inch boards which logs of varying length and mean girth will yield after allowing for bark and waste in sawing; and ready-reckoning tables give the results for logs of all sizes.

2. *Measurement of Standing Trees* is in Britain usually made with tape or a hooked leather strap at about 5 ft. above-ground, the length of the bole being estimated, sometimes by means of a rod 15 to 20 ft. long, and the cubic contents reckoned after allowing for the fall-off to the mean girth. Or if girthed at 5 ft. and the length estimated to timber height of 6 in. diameter or 20 in. girth, then the mean girth is easily found by adding these and dividing by 2; and after allowing for bark, the length is multiplied into the square of the net quarter-girth and divided by 144 to give the saleable contents. But it is far more satisfactory, both for seller and buyer, to agree to prices per cubic foot for defined I and II class timber, and to measure the cubic contents when the trees are felled.

The height of standing trees can be more accurately measured with instruments of various kinds known as hypsometers, dendrometers, &c., which are all based upon the similarity of equal-angled triangles. One of the simplest and best of these is the Telescope Hypsometer, consisting of a hollow metal tube with movable vision-hole at one end and cross-wires at the other, and an adjustable upright rod at right angles to the line of vision; and on this rod being set

at the horizontal distance the observer is from the tree, a plummet hanging from the end of the upright rod indicates upon a graduated scale on the tube the height of the tree. Diameter measurement with callipers is quicker than girth measurement of trees standing in close canopy; and greater accuracy is obtained if two diameters be measured and the mean taken.

3. *Measurement of Whole Crops of Wood* can best be made by selecting fair average sample plots of ½ to 1 ac. each, in such number as may seem necessary, and then measuring the diameters (or girths) of all the stems on each area and registering them tabularly according to each inch of diameter (or 3 in. of girth). The true average stem on each area can be found by



Weise's Telescope Hypsometer.

adding up the number in each class and finding the total on the plot, and then counting back 40 per cent or two-fifths, beginning from the largest class; and whichever diameter (or girth) class this leads one back into, that furnishes the true average stem. One or more of such stems being selected and carefully measured (after felling, if permissible) and the average taken, this will when multiplied by the total number of stems give the cubic contents of the sample area; and so on for each sample area; when the total contents of the whole wood will be such multiple of the total contents of the sample areas as is indicated by the proportion borne by the whole wood to the sum of the various sample areas. [J. N.]

Timber Tables are commonly used in Britain both for giving at once the cubic contents of round logs, measured by the customary formula, length in feet multiplied by the square of the mean quarter-girth in inches (free of bark) and divided by 144 (see TIMBER MEASUREMENT), and also for giving the true cubic contents of squared or sawn timber by multiplying into each other their length, breadth, and depth. In America, Australia, and New Zealand the tables showing cubic contents of round logs are reckoned in 'board measurement', giving the number of superficial feet of boards 1 ft. square and 1 in. thick obtainable from logs of varying size under due consideration as to loss in slabs and sawdust through conversion. In France and Germany, in addition to ready-reckoning tables for round logs and sawn timber, average-yield tables have also been drawn up giving for the chief kinds of trees grown as timber crops (Scots Pine, Spruce, Silver Fir, Beech, and Oak) the total average cubic contents of timber (down to 3 in. diameter at top end) and small branchwood at each ten years from 30 to 100 or 120 years of age, and indicating also the average quantity of material then usually available as thinnings. The tables for each kind of tree-crop are made out for the five different qualities of soil and situation: I very good, II good, III medium, IV inferior, V very poor. As our woodlands are usually so small and scattered, these tables are of little or no use at present; but they serve as giving fairly reliable indications of what British timber crops might yield if grown in large compact masses and continuously under good management. [J. N.]

Timber Trees (in Law).—

TIMBER.—In England the word 'timber' is usually held to mean trees used for the building or repairing of houses, as Oak, Ash, and Elm. The trees must be of a growth of twenty years, and it is said not less than 6 in. in diameter or 2 ft. in girth. This definition of timber is very frequently extended by local custom to include other kinds of trees which have been used in the district for building purposes or in the mechanical arts. Thus Chestnut, Walnut, Cedar, Fir, Aspen, Lime, Sycamore, and Beech trees have by this means been brought under the designation of timber. In Scotland there is no legal definition of the term 'timber'.

TREES.—In England the property in trees is in the landlord of the ground, while the property of bushes is in the tenant. Consequently, a tenant is not entitled to cut down timber trees unless in the case of dead timber, nor is he entitled to cut down other trees where they are planted for some specific purpose, as, for example, to shelter a house. Windfalls of sound timber belong to the landlord, but windfalls of trees which are not timber or of decayed timber trees belong to the tenant. A tenant is entitled to cut down trees for repairs necessary to the buildings or fences on the land, and this even although trees are expressly reserved in the lease, provided he is liable for the upkeep of the premises; he is not entitled to cut timber for repairs which the lessor has agreed to do. In Scotland the property in all trees is in the landlord, and under ordinary agricultural leases they are expressly reserved to him without the necessity for any stipulation in the contract. The tenant is, however, entitled to the yearly fruits, thinnings for repairs, to young willow twigs, &c. If the woods are let as an accessory to the land, the tenant is entitled to cut wood for the necessary repairs of the buildings and fences, but not for sale. In the case of trees growing on the boundary of two estates so that the roots extend into the different estates, it is the law in England that the property in the trees is in the proprietor of the land on which they were first planted or sown. There is little authority on this point in Scotland; but it has been decided that trees on the line of a march were common property and could not be cut

down without the consent of both proprietors, but that if they were distinctly on the side of one or other proprietor they were his sole property, and his neighbour had only the right to demand that overhanging branches should be lopped off. It has been decided in a Sheriff Court in Scotland that a tenant as against his landlord is not entitled to cut overhanging branches which he alleged caused damage to his crop and prevented the use of a reaper and binder on that portion of the field. In the case of fruit trees growing near a boundary, it has been laid down as the law of England that the owner of the fruit trees is entitled to enter his neighbour's land in order to gather up fruit which may have fallen on the other side of the boundary, and the same doctrine has been stated with regard to trees blown down by the wind. But this doctrine would not apply to the case of a tree which had fallen on the opposite side of the boundary while being cut down. In any event, entering on an adjoining property without previous request would be inadvisable. Moreover, the owner entering his neighbour's property for such purpose would be liable to make good any damage done by such entry.

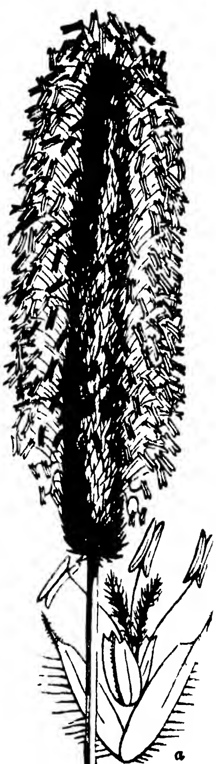
As to damage done to cattle feeding on poisonous trees, see under POISONOUS PLANTS.

[D. B.]

Timber Valuation made while the trees are still standing gives the owner an idea of what any fall he is considering may likely bring him in; and this valuation is sometimes made by the estate agent or factor, sometimes by an expert hired for the purpose, or sometimes by the forester; but the methods adopted are neither scientific nor exact (see TIMBER MEASUREMENT), for the soundness and quality of any standing tree can only be known when it is felled and logged. The more accurate methods of valuing woodlands and growing timber crops are described under WOODLANDS, VALUATION; but certain statutory prescriptions relating to the valuation of woodlands, rating of woods and plantations, and payment of succession duty, may most conveniently be referred to here. Under the Valuation of Lands (Scotland) Act, 1854, the yearly value of woods, copse, or underwood is to be taken at the rent at which in their natural state they might reasonably be expected to let as pasture or grazing lands; and under English law the prescribed standard is much the same. Under the Rating Act, 1874, the land (and not the timber or underwood) is rated, the natural and unimproved value of the land being estimated in the case of woods and plantations, and for copses and underwoods their rental value if let as such. Under the Finance Act, 1894, the annual value of the woodland is to be estimated at its rental value in its natural and unimproved state, and the timber is separately valued. To satisfy the requirements of the Succession Duty Act, the custom in England is to value all the timber and other wood and take 3 per cent as a fair annual income under good management. This income is then treated as an annuity, and succession duty is paid upon it according to a sliding scale annexed to the Act. Thus, if the income from the woods were estimated at £1000 a year, a life-tenant forty years old would only pay as if such annuity had merely a capital value of £14,875 (in place of £16,666).

[J. N.]

Timothy, or **Cat's-tail** (*Phleum pratense*), is a perennial grass which forms much of the hay produced on good meadow land. The plant is composed of a simple tuft of loosely compacted green shoots deeply placed in the ground. The shoots are round and stout, with the leaves rolled round one another. The leaf-blades are broad, light in colour, and have very low flat ribs on the upper surface: from the breadth of the blade Timothy is entitled to the name 'top-grass'. The ear is somewhat late in appearing. It shows about the end of June, and in July flowering commences. This ear is an oblong, compact, spikelike panicle, usually designated a 'cylindrical spike'. It is composed of one-flowered flat spikelets so densely packed that they completely hide the central axis which bears them. The figure shows the ear in flower with the stamens protruded. At *a* a dissected spikelet is seen, with the two glumes lowest, and above them the awnless two-valved husk or pales, then the stamens, and the two feathery stigmas. The length of the ear varies with the soil; on poorer soils it is only 2 or 3 in., but on rich land 7 to 10 in. The height of the straw also varies, but the average may be taken as 3 ft. For hay, Timothy should be cut before flowering, otherwise the produce tends to become rather hard. After flowering and fertilization have taken place, the ear begins to form seed. When the ear assumes a yellowish-red tint, Timothy is ready for seed harvest. The seed is a very small egg-shaped body about $1\frac{1}{2}$ mm. long, composed of a silvery glossy husk containing a rounded grain pointed at the base and finely dotted on the surface. Sometimes the husk is removed by threshing, and then the name 'Shelled Timothy' is applied. Commercial seed is either home-grown or foreign; and although home seed often fetches a higher price in the market, the experiments carried out at the Experiment Station, Kilmarnock, seem to show that it has no advantage over foreign-grown seed. Common impurities are: Bladder Campion, Chickweed,



Timothy Grass (*Phleum pratense*)

a, Spiklet.

Spurrey, Ribgrass, Ox-eye Daisy, Forget-me-not, Self-heal, &c. If Timothy is to be grown along with Red Clover, care should be taken to secure Timothy seed free from dodder. [A. N. M'A.]

Timothy, which got its name from Timothy Hanson, an American, ranks along with the rye grasses as the most valuable grass for mowing which the farmer has. It is extensively grown in the midlands and south-west of Scotland and in some parts of England, and its merits are also beginning to be appreciated and utilized in many districts of Ireland. In the eastern States of North America it is more widely grown than any other natural grass.

Timothy is eminently adapted for growth on cold, heavy clays, and on deep, moist, black lands; but it does not thrive well on thin, dry, sandy, or on calcareous soils, or on badly drained, sour peats. It is extremely hardy against frost, and for this reason often affords good pasture very late in the season. It yields an abundant crop of the very finest quality of hay, which is relished by all classes of stock, and is specially prized for feeding to horses and to milk cows. One of its chief virtues is that it gives a large produce on lands which are too heavy and wet to be successfully green-cropped, and thus it obviates summer-fallowing.

Timothy should be used in seed mixture for leas of short duration wherever the soil is suitable, about 2 to 4 lb. per acre being included; and about 2 lb. per acre may also be included in mixtures for permanent pasture. But its good qualities are most fully utilized when it is sown down to form a Timothy meadow; and wherever conditions are favourable to its growth, farmers would be well advised to lay down a certain area with Timothy. The duration of a Timothy meadow depends largely upon the suitability of the soil, and varies from six up to ten years or even more. Sooner or later, other much less valuable grasses, such as Holcus and Bromus, will become predominant. The meadow must then be ploughed up, and it is often advisable to put under a five or six years course of cropping, finishing with a turnip crop, before attempting to resow with Timothy.

Timothy may be sown out instead of a root crop along with rape, or with Italian Rye Grass and Red Clover. In the former case, the rape must not be allowed to get too large before eating off with sheep; and in the latter, the produce may be fed off with sheep or cut green and fed to dairy stock. Suitable quantities of seed per acre would be 16 to 18 lb. Timothy and 6 to 8 lb. rape; or 16 to 18 lb. Timothy, 6 to 8 lb. Italian Rye Grass, and 2 lb. Red Clover. The more popular method, however, is to sow out with a white crop. The Timothy may be sown alone at the rate of 18 to 20 lb. per acre, or it may be sown along with Italian Rye Grass and Red Clover at the rate above mentioned. The advantage of the latter mixture is that it ensures a full crop of hay the first year after sowing, but if too much Rye Grass be sown there is a danger of the Timothy being smothered out. In any case, the land should be clean and in good tilth; it should be rolled well before sowing the seed, which should be covered lightly by means of the chain harrows, and finally rolled again. It is very bad policy to sow other natural grasses, such as Cocksfoot and Meadow Fescue, along with Timothy, as the latter comes much later into flower, and is not ready for cutting before the other grasses have become hard and wiry. Timothy reaches its full growth about the second or third year after sowing.

To obtain the finest quality of hay it is necessary to cut Timothy just when the bloom is going off the ears. If cutting be delayed till later, in the hope of securing a larger crop, the plants become hard and woody in fibre, more indigestible, and so less nutritious. Of course, if it is intended for seeding, it must be allowed to ripen before cutting. Timothy is the most easily secured of all the grasses owing to its large stems, which allow the drying action to proceed freely and rapidly. When green cut, Timothy is handled in much the same way as ordinary ryegrass and clover hay, the method of harvesting varying according to local custom. But when cut for seed it must be tied into sheaves, allowed to stand in stooks for four or five days, and then put into rickles until dry enough for threshing or stacking. It is usual and preferable to thresh it direct from the rickles.

Where the land is suitable and has been heavily manured, crops of 4 to 5 tons per acre of Timothy may be grown, but a first-class crop would be 3 to 3½ tons per acre; and on poorer soils 1½ to 2 tons may be considered quite a satisfactory yield. The yield of seed varies from 3 to 5 cwt. per acre, according to the soil and stage of growth when cut.

Timothy does not give a very large aftermath, but it continues to grow longer than almost any other grass, and in open seasons will afford pasture all through the winter. In the Carse of Stirling some farmers reckon this winter grazing alone to be worth 15s. to 20s. per acre.

No crop responds better than Timothy to liberal and judicious manuring, and few will give a better return to applications of farmyard manure. Well-rotted farmyard manure is best, and it may be applied in late winter or in early spring at the rate of about 15 tons per acre. After spreading the dung, it is a good plan to put the harrows over the land in order to get more uniform distribution. This should be followed with a topdressing of from 1 to 1½ cwt. nitrate of soda or nitrate of lime per acre, applied about the first week in May. The dung need only be applied about every second year, and in the alternate years 5 cwt. per acre of basic slag applied in the autumn or winter will often give good results. But the nitrate should be put on every year. Where dung is not available, its place may be taken by 4 cwt. superphosphate, 1 cwt. potash manure salt, and ½ cwt. sulphate of ammonia per acre, applied in March, followed by the nitrate as before. On many Timothy lands a dressing of 1½ to 2 tons lime shells may prove very profitable. No crop responds better to an application of liquid manure, wherever it can be secured at a reasonable cost. It always pays to produce large crops of Timothy,

as the land is thereby kept much cleaner, and such weeds as Coltsfoot, so troublesome on clay lands, are effectually choked out.

Timothy has also an indirect value as a soil fertilizer. Its deep roots penetrate far down into the subsoil, promote aeration, and when the land is broken up they form a lasting source of food material to succeeding crops. So that, even though large crops are taken off every year, it is found that, if judiciously manured, the land under a Timothy meadow does not become deteriorated but rather improved. [J. W.]

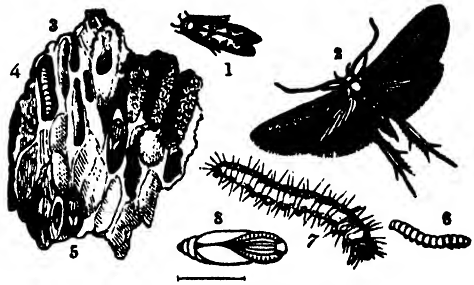
Tinea pelionella (the Common Clothes Moth).—Of all the little moths that infest houses, this is perhaps the worst, the caterpillars destroying every article of wool or feathers. They are small white maggots, about ¼ in. long, with a few hairs, ochreous heads, a slate-coloured line down the back, and sixteen legs. They form cases to dwell in of the material on which they feed, and within this they change to nut-brown pupæ. The moths have a wing expanse of six or seven lines, and are entirely of a satiny buff colour, with black eyes, the wings being deflexed when at rest. They are most abundant in summer and autumn, but the larvæ are feeding all the winter. Camphor, Russia leather shreds, and pepper will keep them out of drawers, and baking infested articles in a gentle heat will destroy the insects in every stage of their existence.

T. (*Scardia*) *granella* (the Little Grain or Corn Moth), also called the mottled woollen moth, does great mischief in granaries and magazines of stored corn. The moths, which abound in spring and summer, rest by day on the walls and beams with their wings closed, and at night fly about in order to pair, after which the female is capable of producing from thirty to seventy eggs, invisible to the naked eye, one or two being deposited on each grain; from these the worms generally hatch in a few days, and eat into the grain, whether wheat, barley, rye, or oats, feeding upon the flour, and if one grain be not sufficient, the caterpillar attaches another or more to it with its web and excrement, until it is full grown, when the corn-heaps are sometimes completely covered with a thick greyish-white web, from the maggots running over them in search of some crevice or chink to change to pupæ.

Whenever the granaries, &c., are empty, they should be thoroughly cleansed, and the walls, ceiling, and beams washed with lime and water, as hot as possible. The floors may also be sprinkled with salt dissolved in vinegar; and salt, mixed with the corn, will kill the caterpillars without injuring the grain. When the larvæ are feeding in the spring and summer, kiln-drying at about 78° F. will kill them; and currents of cold air, by means of ventilators, are a safe and certain remedy, as they become torpid and die if a low temperature be sustained.

A still more satisfactory method is to fumigate with carbon bisulphide, but this should be done by an expert, as the substance is highly poisonous and inflammable.

T. tapetzella (the Woollen Moth) is abundant in houses. The eggs are laid, in summer and autumn, upon woollen clothes, &c., on which the larvæ feed; and as they grow, they form cases to live in; and these often unite the folds in cloth and sacks into masses, when undisturbed. The caterpillars sometimes injure beans, pease, and other seeds, when stored in damp places. They are about ½ in. long, very

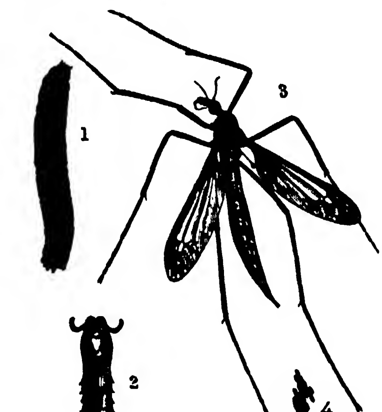


Tinea tapetzella (the Woollen Moth)

Figs. 1, 2, The moth (natural size and enlarged); 3, 4, 6, 7, the caterpillar; 5, the chrysalis; 8, chrysalis (magnified).

active, fleshy, and yellowish-white, with longish hairs scattered over the body. Furs may be preserved from the ravages of this moth by the simple expedient of storing them during the summer in paper parcels carefully gummed up so as to close all apertures. [C. W.]

Tipula oleracea (the Cranefly, or Daddy-long-legs).—The maggots of this large gnat are



Tipula oleracea (Cranefly, or Daddy-long-legs)

commonly known as 'leather jackets', but are sometimes incorrectly called wireworms by agriculturists. They are exceedingly tough, but are destitute of legs. They are of a dirty-clay colour, composed of twelve rings besides the head, with two jaws, and the tail has six spines, enclosing two spiracles (fig. 1). They are most destructive animals in the field and garden, eating through the roots of wheat, oats, beet, cabbages, carrots, potatoes, turnips, scarlet beans,

lettuces, dahlias, carnations, and various flowers, from the end of April to the beginning of August, when they change to pupæ in the earth, of a dirty colour, with two short horns at the head, and spines on the belly; from these the gnats escape in the autumn, leaving the pupæ cases sticking out of the earth, as shown in fig. 2.

The fly (fig. 3) is of a tawny colour; the head is small with two black eyes, the front forming a cylindrical beak, at the tip of which are attached two feelers; the antennæ are short, slender, thirteen-jointed, and dusky, the base tawny; the trunk sub-globose, back ashy, with three obscure stripes; under side and scutel hoary; abdomen clubbed in the male, very long and spindle-shaped in the female; the back slate-colour, with a darker line down the back; the apex horny, and furnished with two slender valves; wings ample, rather smoky, the pinion edge and nervures ochreous-brown; balancers long and slender, with dark clubs; legs bright-ochreous, very long and slender, especially the hinder pair; tips of thighs and shanks with the feet brown, the latter very long, five-jointed, and terminated by two little claws. The wings of the male expand 1½, and of the female 2 in.

The 'leather jackets' are sometimes observed crawling in great numbers over the ground in the early morning. Rolling at such a time kills many of them. Numerous birds eat them with avidity, and therefore frequent harrowing of infested crops is useful. The flies prefer rank grass in which to lay their eggs (fig. 4), and patches in the vicinity of crops likely to prove attractive to them should be rough-mowed.

[J. C.] [C. W.]

Tits (Paridæ).—These familiar and vivacious little birds haunt trees and shrubs in the pursuit of insects, destroying these in all stages of their existence. It has been alleged that Tits destroy buds, but it appears to be only diseased ones that they single out for attention. There are six British species, as follows: (1) Crested Tit (*Parus cristatus*); practically confined to the forests of north and north-east Scotland, and distinguished by its black-and-white crest and the dark black colour of the under side of the body. Weed seeds are eaten as well as insects. The fur-lined nest is made in a hole excavated in the base of a Scots Pine or in a rotten stump. The five to eight eggs are white with red spots. (2) Coal Tit (*Parus ater*); widely distributed through British pine and birch woods, especially where these adjoin open ground. Grey in colour with a whitish breast, the distinctive features are white patches on the sides of the head and back of the neck, and white-barred wings. Seeds are eaten in addition to insects. The mossy nest, lined with hair and feathers, is built in a hole either in a tree or in the ground. The five to ten eggs are white, sparsely spotted with reddish-brown. (3) Marsh Tit (*Parus palustris*).—This rather scarce and local species affects damp meadows and similar places. The prevailing tint of the plumage is brown, lighter below, but the head is blackish, and there are white patches on the sides of the neck. Thistle-fruits are added to the insect diet. The ill-constructed nest is built near the ground in a tree-hole or an excavation made by the bird itself. The five to eight white eggs are speckled with reddish-brown. (4) Great Tit (*Parus major*).—Larger than its allies (6 in. in length), and more useful than any other species except the Blue Tit, this bird is common in almost all parts of Britain. The upper side of the body is dull-green, and the under side yellowish-green, while the head, throat, and a stripe down the breast are black. There is a pear-shaped white patch under each eye. Seeds and small fruits form part of the food in late autumn. It is also known to destroy bats and small birds in order to devour their brains. The nest resembles that of the Coal Tit, and is built in any suitable hole.

Blue Tit and Nest.

The five to nine white eggs are spotted with red. (5) Blue Tit (*Parus cæruleus*).—This is the most beneficial of all the tits, and is widely distributed throughout Britain. The upper side of the body is yellowish-green, and the under side bright-yellow, while crown, wings, and tail are bright-blue. The sides of the head are white, and there is a white line on the brow. Seeds form part of the winter food. The loose mossy nest, lined with hair and feathers, is usually built in a hole. The six to twelve eggs are white with red spots. (6) Long-tailed Tit (*Ægithalus vagans*).—This species, though widely distributed in Britain, is commonest in the south and south-west of England. Its body is smaller than that of allied species, but the tail is relatively very long. Most of the upper side of the body is black, as also are the wings and tail, while stripes of the same colour relieve the whitish hue of head and breast. A characteristic feature is the white edging of wings and tail. Seeds form a smaller part of the food than in other species. The elaborate bottle-shaped nest (hence the local name 'bottle tit') is carefully

made of moss covered with lichen, and cobwebs are used as a binding material. The lining is of feathers. A small hole near the top serves for entry and exit. Dense high bushes and shrubs, or low tree-forks, form the usual building-places. The seven to twelve white eggs are generally, but not always, marked with faint red spots and streaks. So beneficial are all the tits (especially the Blue and Great Tits) that they should be rigidly protected, and if possible helped to tide over severe winters by feeding with suet, beech mast, and acorns; also by providing nesting-boxes, which should be placed in inconspicuous places where cats cannot get at them. The hole for entry should be small enough to prevent an invasion by sparrows (for details see Hiesemann's How to Attract and Protect Wild Birds; Witherby & Co.). Fruit-growers sometimes complain that Great and Blue Tits now and then damage apples and pears by pecking them near the stalk; but even in such cases the good done by destruction of insects far more than outweighs the harm. It has been found that by planting rows of sunflowers in the vicinity of orchards a counter-attraction in the form of the fruits is provided which keeps these birds from the pears and apples. Valuable pears have also been protected by fitting pieces of cardboard 2 in. square round their stalks. [J. R. A. D.]

Toad-flax (*Linaria vulgaris*). 1, Section of flower.

Toad-flax (Linaria) is the common name for a poisonous genus of herbaceous dicotyledonous plants belonging to the nat. ord. Scrophulariaceæ. Various species occur as occasional weeds, but, though poisonous, they seldom injure stock, for they are so nauseous that the animals utterly reject them. A Toad-flax is readily recognized by the two-lipped corolla closed at the mouth like Snapdragon, and by the pocket-like prolongation (spur) on the lower face of the corolla. Common Toad-flax (*Linaria vulgaris*) is a creeping perennial of sandy field with yellow flowers, erect stems 1 to 2 ft. high and glaucous narrow leaves. [A. N. M'A.]

Toads (Bufonidæ), a family of tailless Amphibians, without teeth in either upper or lower jaws, and without ribs. Most Bufonidæ are terrestrial and many burrow, but aquatic and arboreal forms occur. In many cases the body has a thick-set appearance and the skin is very warty. The British toad (*Bufo vulgaris*) is a good representative. It may be distinguished from the common frog in many ways, *e.g.* by its wrinkled, rather dry skin, covered with wart-like poison glands and minute horny spines, by its duller coloration — predominantly grey and brown, by the less developed web between the toes, by the absence of teeth, by the different mode of locomotion—more crawling and less jumping, by being an expert climber, by its marked nocturnal activity, by hibernating far from water, and by laying the eggs in long strings in the water, not in clumps. The poison, known as phrynin, secreted by the skin glands, is volatile and repulsive to many animals; it saves the toad from being molested as often as it might otherwise be. The toad has no power of spitting or squirting its poison. It is a gentle, harmless animal, easily tamed, and very useful to farmer and gardener alike, for it destroys large numbers of slugs and injurious insects. Its food must be alive and moving. The natterjack toad (*B. calamita*), locally distributed in England, Wales, and south-west Ireland, is also a notable insect-eater. The common Indian toad (*Bufo melanostictus*) eats ants and bees; the giant South American toad (*Bufo marinus*) eats large numbers of mosquitoes and the like; the Mexican toad (*Rhinophrynus dorsalis*) feeds mainly on termites. Similar statements may be made in regard to a large number of toads. Old tales as to toads hurting cows' udders and the like are entirely without foundation. [J. A. T.]

Tobacco and **Snuff** may be described as special preparations of the leaves of certain species and varieties of Nicotiana, a genus of herbs of the nat. ord. Solanaceæ. Of the forty-one species that have been described, only two, or perhaps three, are of commercial value, but under each of the economic forms have to be placed many varieties and races. The following may be accepted as the more important:—

1. *Nicotiana Tabacum*, Linn., a native of tropical America, having under it—(*a*) var. *fruticosa*, the narrow-leaved shrubby tobacco, a native of Mexico and Brazil; it affords the races known as Carabobo, China, Nepal, Deniaka, Singapore, and South India. (*b*) Var. *lancifolia*, a native of South America, is the source of the Domingo, Kentucky, Burley, Cattaro, Kashmir, and other Indian hill tobaccos. (*c*) Var. *virginica*.—This came originally from the Orinoco, was introduced by the English planters into

Virginia, and has given among others the Big Orinoco or Virginian Broad Leaf, Yellow Orinoco, Blue Pryor, Yellow Mammoth, Golden Leaf, &c. (*d*) Var. *brasiliensis*, the *petum* of Brazil, a native of that country and of Guiana, Venezuela, and Bolivia. It embraces the following special races—Brazil, Bahia, Paraguay, Pernambuco, Florida, Maryland, Ohio, &c. (*e*) Var. *havanensis*, indigenous to Mexico, but early carried by the Spaniards to Cuba, and the most highly valued Havana tobacco, of which there are many races, such as Havana Seed-leaf, Connecticut, Pennsylvania, Wilson's Hybrid, Zimmer's Spanish, Manila, &c. (*f*) Var. *macrophylla*, a native of Mexico, but now the chief form grown in Northern India, Persia, Egypt, Peru, &c. It affords much of the so-called Marylands of modern commerce, also of Cuba, Varinas, Venezuela, Makala, Saloniki, Argos, &c.

2. *N. rustica*, Linn., a smaller plant than the preceding, and which has orbicular leaves with distinct stalks, and is leathery in texture, with pale-greenish-white, short but wide flowers. Collectively the tobaccos of this species are usually classed as Turkish or East Indian. The various grades of snuff are mainly made from one or other of its forms. It was probably originally a native of Mexico and Texas, where it is still known as the *picietl*. There are numerous varieties and cultivated races placed under it, of which the following may be mentioned: (*a*) var. *texana*, the form early grown in France; (*b*) var. *jamaicensis*, met with in Jamaica, Guatemala, &c.; (*c*) var. *brasilia*, often called *fumo-crespo*, and frequently used for snuff; (*d*) var. *asiatica*, the chief source of Syrian, Arabian, and much of the Persian and Abyssinian tobaccos, which are sometimes designated the common or English tobaccos, and when made into snuff is held to be superior to most other grades; (*e*) var. *humilis*, largely used in the manufacture of snuff, specially that in favour in Germany.

3. *N. alata*, Lk. et O., a native of Brazil, and cultivated in gardens in Europe, Persia, &c. This is supposed by some to be the chief source of the *tumbeki* of Persia: by others that tobacco is regarded as owing its peculiar properties to the soil on which grown, the method of treatment, &c., and not to the stock of plant actually raised.

The commercial classification of tobaccos is naturally based on the purpose for which each grade is suited: (*a*) Cigar-wrappers—the outer leaf of the cigar—for which the most highly prized are the Sumatra, Connecticut, Havana, &c.; (*b*) Cigar-fillers—the leaf placed in the interior of the cigar—such as Cuban, Zimmer's Spanish, &c.; then comes (*c*) Pipe Tobaccos, of which mention may be made of North Carolina, Bright Yellow, Maryland, &c.; (*d*) Plug Tobaccos—White Barley, Orinoco, Yellow Mammoth, Virginia, Blue Pryor, White Stem, &c.

Tobacco was not known in Europe and Asia prior to the year 1492, when America was discovered. Of Europeans it was first seen by the followers of Columbus when they landed at Cuba. In 1531 the Spaniards commenced to cultivate tobacco in San Domingo; in 1535 seed was brought to Europe; and in 1560 Nicot (in honour of whom the genus was named) saw the plant being grown in Portugal, and sent seed from there to Catherine de Medicis. In the same year, tobacco was conveyed to England by Thomas Hariot, Sir Francis Drake, and others; while from 1570–84 Sir Walter Raleigh made tobacco-smoking popular in England. In 1596 Ben Jonson in Every Man in his Humour gave the arguments for and against tobacco; while King James I issued his Counterblast in 1603, and raised the tax to 6s. 10*d*. on the pound.

Tobacco Plant—Flower and Leaf

King Charles in 1630 prohibited the cultivation in England and Ireland, where, according to Macpherson, great quantities were being grown. By an Act of 1663 cultivation in England was again prohibited, and Charles II, by an Act of 1670, compelled the imports intended for Ireland to be conveyed in the first place to England. In 1731 Virginia and Maryland were regarded as most valuable to England because of their tobacco, so that in spite of all opposition the weed had apparently assumed a position of importance. By a special Act of George III, 1780, tobacco cultivation in Ireland was allowed, but not in England nor in Scotland; and lastly, in 1830 William IV again prohibited the Irish cultivation. The repressive legislation of the British Government was entirely a consequence of the desire to favour the then British colony of Virginia. Recently experimental cultivation in England, Ireland, and Scotland has been authorized; and the success so far attained

During the reign of Queen Anne the annual revenue from tobacco was £250,000; and to-day it comes to well over 13 millions sterling, after an allowance for drawbacks on re-exports. The average imports for the past five years have been: manufactured tobaccos of all kinds, valued at from 1¼ to 1¾ million sterling, and unmanufactured from 2½ to 3 millions sterling. The corresponding weights were, for manufactured tobaccos, 3½ to close on 5 millions, and of unmanufactured, from 86½ to 119 millions of pounds. These imports come mainly from the United States of North America, followed by Cuba, the northern States of South America, Manila, Borneo, and British India. But of these quantities imported, a considerable proportion of the raw stuff is worked up in bond and either exported, or used in Great Britain itself, so also a certain share of the foreign imports are re-exported. Of these exports, the British manufactured tobaccos sent outside the country in 1907 came to 14,709,784 lb., valued at £1,262,498; and the re-exports during the same year were 4,557,083 lb., valued at £217,365, manufactured and unmanufactured together. In the consumption of tobaccos Belgium comes first with 5·50 lb. to the head of population; then Holland, 4·40 lb.; Germany, 3·30 lb.; Austria, 2·75 lb.; Norway, 2·24 lb.; Russia, 1·83 lb.; France, 1·78 lb.; Great Britain and Ireland, 1·72 lb.; and Spain, 1·08 lb.

For successful cultivation tobacco requires a rich sandy loam, containing a distinct percentage of potash and lime, together with plenty of vegetable matter. Good tobacco cannot be raised on poor soils, unless heavily manured, while clay and calcareous soils are unsuited. In some of the best localities (of India, for example) water is so near the surface that temporary wells can be formed throughout the fields; but while subsoil moisture is desirable, good drainage is indispensable. A humid atmosphere during the early months of growth is essential. While all the species are natives of the Tropics, tobacco cultivation is pursued during the colder months of warm tracts and the hotter of cold regions, so that as a summer crop its production has been extended into the temperate countries; in fact the greater proportion of the leaf of commerce is obtained from the temperate States of America, and a considerable proportion is even now raised in Europe. The land must be deeply and thoroughly ploughed and cross-ploughed, lime ashes and farmyard manure being liberally applied before the last ploughing; in this way the weeds are killed and the soil made friable. It is then thrown into furrows 6 in. deep and 3 ft. apart. Nurseries are also prepared in a shady situation, the soil of which is usually burned along with the weeds and all the brushwood available. This kills injurious germs, and the ashes produced check the growth of insects, besides being a highly beneficial manure. In about six weeks the seedlings will be ready for transplanting, and will be from 3 to become necessary. After two or three leaves have formed and the plants have begun to grow vigorously, the earth may be pulled down gradually around the stems until the furrows are filled up, and the plants then stand on slightly raised ridges.

In from thirty to forty days from transplanting, the flower buds will appear, and these must be carefully nipped off; and a little later, when lateral shoots begin to show in the axils of the leaves, these also must be removed, so as to force the plant to concentrate its efforts in the formation of leaf. At this stage there should be from eight to twelve leaves to each plant. As soon as these have attained the required maturity, the plants must be cut down to the ground with a sharp knife. It is usually found that harvest time has been reached in from two and a half to three months from sowing time. The surface of the leaves will be then gummy, the texture appear granulated, the colour become greenish-yellow with irregular paler-coloured blotches, the edges and tips will have curled, while if bent backwards they will break off. Before cutting the plants, in many parts of the tobacco area it is customary to construct a crude framework through the field in rows. This consists of forks driven into the ground, and so adjusted as to carry sticks of a uniform length, say 6 ft. long. The plants are then taken in hand one by one and cut up into pairs of leaves. The good leaves are thrown over certain sticks and the inferior ones over others. Thus assorted, they are left to dry and wither in the sun; but if rain or heavy dews come, they are at once carried within doors, and the sticks with their leaf placed across beams fitted for that purpose within the drying-house. In some localities the pairs of leaves are simply spread on the ground for an hour or two to dry, and are then carried to the withering-house and hung across sticks in the way described. But there is great skill in drying. Rapid drying will produce pale leaf, and slow drying dark-coloured leaf. When the midribs are quite dry (and usually this takes some thirty days) the pairs of leaves, or portions of stems and attached leaves, are then ready for the next operation. They are taken down, separated from thick useless stems, and placed in heaps on the floor to ferment or sweat. For this purpose they are flattened out carefully and built into circular stacks, the stems or leaf-stalks being pointed inwards and the leaves outwards. It is preferable to select a damp day for this work. Separate stacks are built up of the finer leaves by themselves. The stacks may be from 2 to 6 ft. high, and it is customary to cover them over with cloth. After one or two days the stacks are pulled down and remade, two stacks of one quality being dealt with simultaneously, so that a leaf from one and the second from the other may be used in construction of the new stacks. Care is also taken to secure that leaves that were in

weeks. Uniform and continuous fermentation is thus secured.

It will accordingly be seen that dried leaf of *Nicotiana Tabacum* is not necessarily tobacco. The fermentation, to which the dried leaf has to be subjected, is essential. Oxidizing *enzymes* are the principal agents in producing the colour and aroma characteristic of the carefully prepared leaf. Three distinct forms have been recognized: the first is called *oxidase*, and is an exceedingly active ferment, but destroyed by a heat of 150° F.; the second, *peroxidase*, is more resistant, and only destroyed at 190° F.; while the third, *catalase*, is more resistant still. The changes effected by these ferments are very striking. During the drying of the leaf the starch is transformed, and the greater part of the sugar thereby produced in time disappears. The albuminoids and the tannin decrease, and the change in colour is accomplished at the same time. In the sweating stage the last trace of sugar should disappear, the *nicotine* decrease, but the resulting *amides* increase. The leaf becomes distinctly alkaline, and the aroma is greatly developed.

After the stacks of leaf have become cold, the changes briefly indicated have been accomplished. The leaves are then ready for being tied together into fan-shaped bundles, often called 'hands'. The string used is an unsound leaf twisted into a rope. It is most important, in this operation, that the leaves should be retained in a perfectly flat position, and to attain this the greatest skill is necessary. The form and size of the 'hands' is as a rule peculiar to each country or grade of tobacco. It is also necessary to ascertain the amount of moisture present in the leaf, since that will affect the amount to be paid, on its being carried to countries with an import duty. In England the standard may be spoken of as 10 per cent, but great differences exist in the drinking qualities of tobacco. In the manufactured state, 100 lb. of tobacco will usually contain 65 lb. of actual leaf, the rest being water. It thus follows that the incidence of import duties will be immediately affected by the amount of moisture present. The 'hands' of leaf are packed carefully into bales, boxes, or hogsheads, and it is of importance to compress the leaf as much as possible, so as to exclude air and prevent the absorption of moisture. [G. W.]

Tobacco Growing in Britain.—Though several species of the tobacco plant are in cultivation, nearly all the tobacco of commerce is the product of one species, *Nicotiana Tabacum*. This species has become adapted to a wonderful variety of soils, climate, and methods of culture, all of which affect, in some degree, its quality or characteristics, and thus give rise to the endless number of varieties now in cultivation. The tobacco produced by every country and district has distinct characteristics, and the trade recognizes this by dividing cured tobaccos into classes, according to their use; into types, according to sideration must be given to the nature of climate, soil, market demand, and to the relation between cost of production and selling price. Extensive commercial experiments conducted by the Irish Department of Agriculture have shown that pipe tobacco is the easiest to produce and sell; that cigarette tobacco of rather distinct type can be produced by methods well adapted to the climate, but it is not easy to find a market for it; that a cheap cigar or fermented tobacco, which seems best adapted to this climate, is in least demand in British markets.

Climate and Soil.—In this climate the tobacco plant will not fully mature in less than 100 days. Though cold nights retard growth and narrow the leaves, the plant can withstand a few degrees of frost without injury. The cool moist atmosphere of the British Isles makes the tobacco plant to a large degree independent of variations in soil moisture, which in drier and hotter climates is a prominent factor in determining the type of tobacco a soil is adapted to produce. Almost any good tillage soil may be made to produce tobacco, but it flourishes best in a free open soil well stocked with vegetable mould and plant food.

Varieties.—The most suitable varieties of pipe tobacco are Yellow Orinoco for earliness, Yellow Pryor for medium size and earliness, and selected Blue Pryor for large leaves specially suitable for plug and roll wrappers. For cigarette tobacco the bright Samos variety is distinctly superior. For cigar wrappers the Sumatra variety, imported from Connecticut and acclimatized, produces the highest type of wrapper; but Halliday, a Connecticut hybrid variety, is not so delicate and liable to injury. Halliday is also superior to other varieties for the production of cigar bunch wrappers. Even the best varieties are unreliable unless they are kept perfectly true and uniform by careful seed selection. Seed should be procured from only tobacco-seed specialists or careful tobacco growers. The best seed should test fully 75 per cent good, and one ounce will easily yield 70,000 good plants.

Cultivation.—Seed should be sown from the middle of March to the middle of April in tight, glass-covered hotbeds heated by horse manure. If sown at the rate of $\frac{1}{64}$ oz. of best clean seed to each (6 by 4) foot sash, this area may be relied upon to produce from 1200 to 1500 plants fit for the field within a period of six to eight weeks. Fields for tobacco must be very well sheltered, and free from slugs, wireworms, and leather-jacket larvæ, which destroy the young transplants. Tobacco may be substituted for an ordinary green crop in many rotations, or may succeed itself indefinitely with proper manuring. In order to produce the rapid growth and maturity so necessary for the tobacco plant, the soil must be in the very finest condition.

Manures affect both the quality and yield of tobacco. For quality, an excess of nitrogen and phosphate and all chlorine manures should be avoided. Potash should be abundant if high-

burning quality is desired. The most economical and effective system of manuring for this country is to broadcast 20 to 30 tons of well-rotted manure in the autumn or early spring, and apply from 6 to 12 cwt. of readily available artificial manure in the drill 'back of the scraw' immediately before planting. The formula which has given the most general satisfaction in the Irish experiments consists of:—

30 parts sulphate of ammonia, equal to 5·76 per cent nitrogen.
54 parts 35-per-cent superphosphate, equal to 17·5 per cent soluble phosphate.
16 parts sulphate of potash, equal to 7·6 per cent potash K_2O.

In this climate properly hardened plants will withstand five degrees of frost, but it is scarcely safe to begin planting before the 20th of May. Planting should be completed as soon after the 1st of June as possible. The distance between plants has a pronounced effect upon the quality and characteristics of the cured tobacco, and should vary with the type of tobacco grown, with the soil, and with the climate. The varieties recommended should be planted as follows:—

Class	Variety.	Distance in inches between—	
		Drills	Plants.
Pipe	Pryor	36	24
	Orinoco	36	20
Cigarette	Samos ...	30	9
Cigar	Sumatra	36	12
	Halliday	36	12

Tobacco should be planted on very low flat drills, and in cultivation the roots should be kept well covered. Weed growth should be absolutely prevented by frequently stirring the soil, deeply at first, and then more shallow as growth proceeds.

Topping.—The practice of topping or removing the seed-head should vary with the class and type of tobacco. Tobaccos requiring large thick leaves should be allowed to bear about ten leaves, while Samos cigarette and Sumatra cigar varieties should not be topped at all, in order to keep the leaves of Samos small, and of Sumatra delicate and thin. The Halliday variety should have the flower-head and a few top leaves removed when the lower leaves are turning ripe. All suckers or lateral growths should be broken off when 4 to 6 in. long. Ripening is hastened by the topping and suckering operations. Ripeness is indicated in the leaf by curling of the edges and drooping, change of colour and texture, loss of smoothness and gloss, increase of body and brittleness.

Harvesting.—As all of the leaves on the plant do not ripen at once, the highest-class cigar and cigarette varieties are harvested by removing the leaves as they ripen from the ground up. With lower-class tobaccos, notably pipe varieties, the entire plant is harvested when the middle leaves are fully mature. The lower leaves of Sumatra and Samos varieties may be fit to harvest the latter end of July, and all of the leaves may be gathered before the 1st of September; whereas the Pryor, Orinoco, and Halliday varieties will not be ready for harvesting on the stalk until the 1st of September or later. It is desirable to harvest tobacco after a few bright days have caused the natural oils and gums to accumulate in and on the leaf. A sunny day is also a great advantage when harvesting, as the rapid evaporation causes the leaves to wilt, which permits the plants to be handled without breakage, and housed in less space without danger of subsequent mould and rot. Placing the cut plants upon scaffolds in the field also serves the same purpose. From five to eight plants are speared through the lower ends of the stalks on a lath 4 ft. long, 1½ in. wide, and ½ in. thick. When the leaves are harvested separately they are strung with a needle, and the ends of the twine are attached to the ends of light 4-ft. laths. These laths of either leaves or plants are carefully placed in the curing barn on horizontal supports so arranged that the whole interior may be filled with tobacco and yet admit the air to every plant and leaf.

Curing.—Curing barns may be designed to afford mere protection from inclement weather, or for the more difficult purpose of regulating the temperature and humidity to an exact degree. New tobacco barns should be constructed of wood. A convenient height and width is 20 ft. They may be of any length, though small barns are best. Ventilators should be abundant, evenly distributed, easily controlled, and arranged to prevent rain from beating or blowing in. A new wooden barn to accommodate the produce of 2 ac. of Pryor tobacco, suitable for both tobacco curing and cattle feeding, may cost £80. Existing structures of many kinds may be cheaply converted into curing barns by providing controlled ventilation, supplying simple means of heating, and erecting supports or racking on which to hang the tobacco plants.

Curing is not merely drying, but is a chemical process the exact changes and reactions of which cannot be fully explained. Sun curing is not feasible in Britain. Air curing, when supplemented in unfavourable weather by some simple means of heating, is a success with all of the types recommended excepting Samos, which should be cured rapidly by artificial heat. Heat may be supplied cheaply by means of stoves, coke braziers, or in the case of certain tobaccos, by means of open hardwood fires and peat fires handled in a special manner. British markets take large quantities of fire-cured pipe tobacco, but cigar and cigarette tobaccos should never bear the odour of smoke. Curing proceeds by the following stages:—

1. Wilting.—The leaves should lose moisture rapidly and become limp, but drying should not proceed too rapidly, else the green colour will be fixed.

2. Yellowing.—Their colour gradually changes from green to yellow, beginning at the tips and edges of the leaf.

3. Browning.—The yellow colour gives place to brown in the same manner.

4. Fixing.—As the brown colour runs the leaf

should lose its surplus sap, otherwise mould and rot will set in.

5. Killing.—When the brown colour is spread and fixed in all the leaves, the midribs must be killed or dried out thoroughly in order to prevent mould and rot. The leaves are then in condition to strip from the stalk and grade.

Preparation for Market.—The preparation of tobacco for market involves the operations of grading, bulking, fermenting or sweating, ordering, packing, and ageing. In tobacco-producing countries these operations are not usually performed, except in a temporary way, by any but the largest growers. The tobacco, graded roughly or not at all, is sold either loose or in rough packages to middlemen, called rehandlers. It is their business to grade, prepare, and pack the tobacco for special markets with which they are in touch. These facilities cannot exist, however, in the experimental stage of the industry.

Grading.—Each type of tobacco is graded differently. Sumatra tobacco is graded, after fermenting, into as many as seventy grades. Pipe tobacco is graded as the leaves are stripped from the stalk into three grades.

Fermentation.—All tobaccos undergo some degree of fermentation before they are fit to use. It may be violent and rapid for cigar, moderate for heavy pipe tobacco, and mild and prolonged for cigarette. Cigar tobacco is fermented for six weeks to three months in large orderly piles. Pipe tobacco is sweated and cigarette tobacco is slowly matured after being packed for market.

Packing.—Cigar and cigarette tobaccos are packed in bales weighing from 100 to 300 lb. Pipe tobacco is packed either in bales or hogsheads, and in order to reduce its moisture to suit commercial requirements it is superdried, and then brought into order for packing by means of steam vapour. Very expensive apparatus is used for this purpose by American rehandlers.

Marketing.—It is very difficult to develop a market for a new tobacco, for the reason that tobacco manufacturers are very conservative and look askance at an unknown product. If it is a tobacco of merit, however, it may eventually gain recognition and gradually develop a reputation. In the meantime it may find a sale owing to a general scarcity of tobacco in the markets, or by being offered at a very low price. It is far more difficult to establish a reputation for quality than for cheapness, but the production of a cheap inferior tobacco seldom pays. All tobacco leaf sold and consumed in the United Kingdom must pass through a bonded warehouse, where duty must be paid upon the net weight of tobacco before it is withdrawn for manufacture. The tobacco may be sold through a broker or direct to the manufacturer.

Results.—Yields vary greatly with the soil, manuring, and type of tobacco grown. The varieties recommended will yield from 900 to 1500 lb. of dry tobacco per acre, and the price will vary from 4*d.* per lb. for pipe tobacco to 1*s.* per lb. for cigar wrappers. The cost of production, including every legitimate charge, is not less than £20 per statute acre for pipe tobacco, £35 for Samoa, £40 for Halliday, and £50 for Sumatra. Many of the charges for attendance and oversight included in these estimates might be omitted in the case of a farmer who does his own work with the assistance of his family. It is not likely, however, that the profit can be made sufficiently attractive to the British farmer without Government help or protection, especially at the beginning, when he is learning to grow a crop with which he is quite unfamiliar. Tobacco is regarded as a valuable farm crop for the reason that it affords a large amount of fairly regular employment, and because the produce, when properly packed, is non-perishable, and may be cheaply transported to distant markets.

[G. N. K.]

Toggenburg Goat.—Of the four principal Swiss varieties this is the most esteemed as a milker, especially in England. It is met with throughout the canton of St. Gall, but especially in the valley whence it derives its name, and where great pains are taken to breed it pure to type. The unique drab tint of the coat may best be described as mouse-coloured, and it has certain white or greyish markings which are also a feature of the breed. There is always a streak of grey down each side of the face, the same colour being noticeable on each side of the tail, under the body on the interior of the thighs, and on the legs as far as the knees. In Switzerland both long- and short-haired specimens are met with, but in England the former are discountenanced. On the other hand, with us there are many possessing horns, whereas in their native valleys these are rarely seen, as the Swiss breeder destroys any kids that possess these attributes. The ears in this breed are of medium size and as a rule pricked, though sometimes carried in a horizontal position. Some remarkable yields have been recorded from milking prize stock in England. A herd of five goats belonging to Mr. Gates of Guildford gave in one year 7140 lb. of milk, or about 714 gal., whilst a three-quarter-bred goat belonging to Mr. B. Hook of Churt, Surrey, gave in ten months 1025 lb. See also Goats, Breeds of.

[H. S. H. P.]

Tomato.—The Tomato or Love Apple *Lycopersicum esculentum*) is a tender annual introduced from South America about the same time as the potato, and extensively grown in the warmer parts of Europe for its fruit, but only recently valued in this country, although long grown by lovers of the curious as a decorative plant. Closely related to the potato and the aubergine, the Tomato is distinguished by its unarmed procumbent stems, unequally pinnate leaves, green above, glaucescent beneath, and more or less hairy, and its large, fleshy, multicelled fruits containing numerous seeds embedded in a soft, juicy pulp. Under cultivation it has varied chiefly in the size and form of its fruits. There is also considerable variation in the thickness of the skin, and in the flavour and juiciness of the pulp. Upwards of a hundred named varieties are in cultivation in this country alone. Many of these, however, are scarcely distinguishable from each other, a difference in quality being due to a slight difference in strain, also to the care exercised in the culti-

vation and selection of the plants from which seeds are saved.

Cultivation out-of-doors.—Notwithstanding the tender nature of the Tomato, it may be successfully cultivated in the open air in summer in the warmer parts of the British Islands, and if favoured with hot, dry weather excellent crops of good-quality fruits are produced with very little outlay. Soil that will grow potatoes will also grow tomatoes, and their cultivation does not differ much, except that the young plants require protection until the end of May, when they may be planted outside, and as the stem elongates it is supported with a stout stick. Plants for this purpose are raised from seeds sown early in April and placed in a little warmth to germinate, transferring them singly into 3-in. pots as soon as they have formed two true leaves, and keeping them in a warm house or frame for a few weeks. They may then be brought along with such plants as geraniums and fuchsias, affording them plenty of light and air when the weather is favourable, so as to keep them sturdy. An open, sunny border, shaded from wind, having been prepared for them by digging, they may be planted 3 ft. apart and at once well watered. Blank spaces on walls devoted to fruit trees or in front of a house facing south may be utilized for tomatoes, or they may be put in deep frames previously used for wintering tender plants, where they may be nursed along by a judicious use of the lights until they are strong enough to be permanently exposed. The main shoot should be supported by a stout stick 4 ft. or 5 ft. high, or if against a wall, with a tie here and there. All lateral shoots should be pinched out early so as not to interfere with the development of the flower raceme produced from the leaf axils on the main stem, and on which the fruits are borne. It is not necessary to remove any portion of the leaves from the main stem. The fruit should commence to ripen from July onwards. After September it is advisable to remove all the full-sized green fruits, and place them in a warm room or on a shelf in the greenhouse, where they will soon ripen and develop colour.

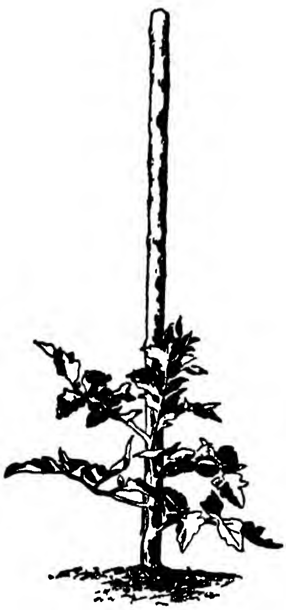


Fig. 1.—Stout end Stake, with Tomato Plant, showing type usually planted by market-growers

Fig. 2.—Bamboo Cane, with Tomato Plant turned out of 6 inch pot

The market gardeners who grow tomatoes on a large scale out-of-doors prepare the ground by manuring it well in advance of planting time. Some use a chemical manure made up as follows: Nitrate of soda 4 cwt., superphosphate 8 cwt., sulphate of potash ¾ cwt., sulphate of iron ½ cwt. per acre. They set the plants 15 in. apart with 3 ft. between the rows, otherwise the treatment is similar to that already described.

The cultivation of tomatoes under glass is now an important industry. They are most profitable as an early summer crop, when, if marketed in June, the fruit realizes something like 8*d.* per lb. They are grown as a rule in pots or boxes, the plants being raised from seeds sown in January, and the young plants treated to tropical conditions, keeping them close to the glass, where they will get plenty of light. They are finally planted in 10-in. pots and placed in rows in low, light houses; the soil used for them is a pure loam without manure, this being supplied later if necessary when the fruit is maturing. While the house is kept warm, the minimum temperature never falling below 60° F., plenty of ventilation is provided, which is necessary to prevent outbreaks of disease. The plants are liberally supplied with water at the root, that is, they are well watered when dry. When in flower it pays to assist fertilization by tapping the flower racemes with a twig, at the same time keeping the temperature rather high. The main crop of tomatoes grown under glass is obtained from plants that are put into their fruiting pots or boxes in April, or if the houses stand on soil that is suitable they may be planted out. Magnificent crops have been obtained where light houses have been set up over good agricultural soil in which the tomatoes have been set about 2 ft. apart, and trained either along the roof or to stakes set upright, restricting the growths by pinching, and encouraging the development of flower racemes in the leaf axils of the main stem. The secret of success with tomatoes under glass lies principally in the ventilation and the maintenance of a regular temperature.

When the light is good a high temperature with ventilation affords the ideal condition. The question of succession is one of adjustment to means. Tomatoes may be grown so as to ripen their fruits at any time of the year. They are difficult to bring to perfection in midwinter, but where the conditions are favourable winter crops will pay, although the competition of imported tomatoes of very fair quality is now very keen.

The diseases which affect tomatoes are somewhat numerous. They are subject to the potato disease. Yellow Spot is very troublesome on plants grown under glass, being encouraged by a warm, stagnant atmosphere, whilst it is prevented by maintaining warm, dry, airy conditions. Black Stripe is a most troublesome disease; it attacks the roots, and causes discoloration of the stems and malformed fruit. Sleeping disease is somewhat similar. Both of them may be kept in check by the use of lime watered into the soil. Black Rot attacks the fruit, causing black circular patches. It is usually favoured by a sudden fall of temperature with excessive moisture.

A selection of the best varieties would include the following: *Frogmore Selected*, a strong grower and heavy cropper; *Ham Green Favourite*, one of the best for market; *Satisfaction*, a heavy cropper, the fruit of medium size, smooth, and bright-crimson colour; *Magnum Bonum*, first-rate for cultivation under glass; *Winter Beauty*, much appreciated for a winter supply; *Lister's Prolific*, a variety of recent introduction which has exceptional cropping qualities; *Earliest of All*, very prolific, the fruit of medium size and a bright-red, one of the best earlies; *Peachblow*, with fruit coloured like a peach, and of excellent flavour. In addition to the above, which are red-fruited, there are several varieties of superior quality with yellow fruits, but they do not sell well. *Sunbeam* has egg-shaped fruits of a rich amber colour, and delicious in flavour; *Golden Nugget* is very prolific, and has globular fruits coloured golden-yellow. Other distinct varieties have long racemes of cherry-like fruits coloured either red or yellow. The best red is known as *Cascade*, and the best yellow as *Dwarf Gem*.

[W. W.]

Tomato.—Parasitic Fungi.—The following are some of the more common diseases of tomatoes:—

(*a*) Black Rot chiefly attacks fruits, causing dark sunken spots lined with a brownish velvety coating of spore-bearing branches of *Macrosporium*.

(*b*) Fruit Rot (*Alternaria*) forms greenish-brown velvety patches with white margins.

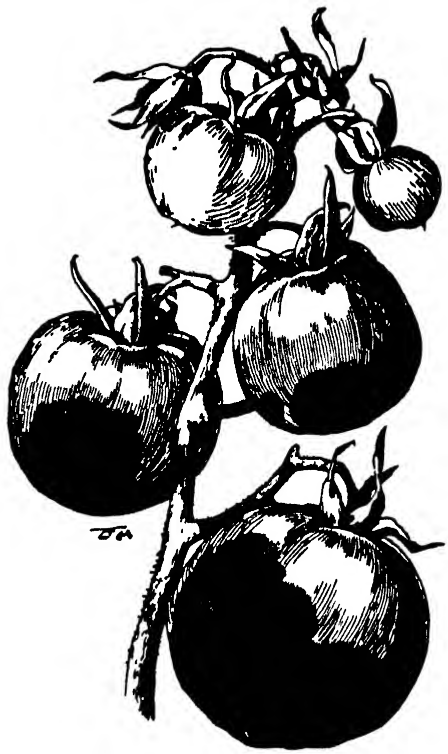
(*c*) Bacterial Fruit Rot reduces young fruits to a decaying mass.

(*d*) Leaf Rust occurs on the under side of leaves as a velvety rusty-brown coating of spore-bearing branches of *Cladosporium fulvum*; leaves and young fruits turn brown.

(*e*) Potato-disease fungus also destroys tomato foliage (see POTATO DISEASE).

(*f*) Leaf Spot (*Septoria*) appears first as blackish-green spots on the foliage, and the plant rapidly dies. This disease is so destructive that it is scheduled under the Destructive Insects and Pests Act (Order of 1910) as a pest to be notified to the Board of Agriculture.

Treatment.—These fungi are more liable to attack plants under glass, hence attention should be paid to ventilation. Other general measures recommended by growers include frequent lime-washing of houses, also fresh soil every two or three years with burnt garden refuse added, and animal manures to be used sparingly. Prompt removal and burning of rotting fruits or plants will help to save the



Bacterial Disease of Tomatoes

rest. Where these measures fail, fungicides have been used with success. Medium Bordeaux mixture (see FUNGICIDES) and potassium sulphide (3 oz. in 10 gal. water) are both recommended for most of these diseases, but spraying must begin as soon as disease appears, and be frequently repeated. The following treatment also produced healthy crops of tomatoes and cucumbers: Commence watering when plants are a fortnight old, every third day with a solution of copper sulphate (1 oz. in 50 gal. water); after six weeks, water every fourth day with a stronger solution (1 oz. in 35 gal. water).

[W. G. S.]

Tongue, Diseases of and Injuries to.—The tongue is subject to eruptive diseases in sympathy with the stomach, or as a symptom of some systemic condition in foot-and-mouth disease, to blaine, gloss-anthrax, actinomycosis,

cancer, and tubercular deposits commencing in the glands and extending into the muscular substance of the organ. So long as the mouth is kept shut, the tongue occupies a peculiarly favourable position for recovery from disease and injury; but if the animal is for any reason unable to close the cavity and keep the organ moist, an ill odour and unfavourable conditions are set up. The dense covering upon the upper surface does not extend to the sides, and ruminants are much more liable to abrasions and the entrance of the ray fungus than horses (see ACTINOMYCOSIS). Irregularities of the teeth are a frequent cause of abrasions and of local inflammations of a more or less septic character, where food is retained in the interdental spaces and has undergone decomposition (see TEETH, DISEASES OF). The lodgment of foreign bodies, as brambles and thorns, and the obstruction of the duct of the sublingual gland by an oat, or salivary calculus, are to be reckoned among the causes which give rise to swelling and inflammation of the tongue, sometimes to an extent threatening suffocation. Injuries are of very much more frequent occurrence than disease—and this applies more to horses, mules, and asses—through the use of the bit, and improper methods of control still too common among stablemen, who do not fear to put the twitch on the lingual member of a stubborn animal. Horses receive injuries from jointed bits, seldom from straight bars. Falling on the mouth—'pecking' as hunting folks have it—often results in biting the tongue. Crib biters and mischievous animals have occasionally to pay the penalty of their behaviour by lodgment of splinters, and the tearing asunder of the tongue in chains and by spring hooks. Treatment of eruptive troubles will of course be constitutional primarily, and will be found under the diseases mentioned above, but local applications are nowhere more successful than when applied to this organ. Solutions of alum, and borax, and honey serve to give relief in almost all tongue sores, including the great ulcers resulting from foot-and-mouth disease. Sponging with permanganate of potash, 2 per cent, with chinosol, chlorinated lime water, chlorate of potash in solution, and other simple disinfectants soon relieves unhealthy and languid ulcers from which the tongue suffers in common with the gums. [H. L.]

Tonics. — The veterinarian gives a wider significance to the word 'tonic' than is generally understood by the public. Pure air or a run at grass may prove a tonic for the stabled animal, as well as those drugs and chemical substances which either supply some element wanting, or call forth the latent vital forces in a manner more lasting than do stimulants. There are general tonics, as iron and the bitter vegetable extracts; nerve tonics, as quinine and nux vomica; heart tonics, as digitalis and strophanthus. The exact manner in which certain tonics act upon the various organs, as the liver and kidneys, the stomach and pancreas, the gastric and peptic glands, may not be very clear; but the practice of medicine is still largely empirical, and experience has accumulated of a kind that is very helpful to the general practitioner, who prescribes the various tonics with a large measure of success; restoring digestion and assisting in assimilation, and the renewal of tone and constitutional power after exhausting illness, or loss of blood, nervous shock, and the debility incurred by parasitism. [H. L.]

Tonquin Pigs are similar in colour, form, and characteristics to Chinese pigs (see CHINESE PIGS), and were said to have been used in the improvement of the Small Yorkshire, hence the name Tunky or Tonquin by which the latter pigs were frequently called in the midland counties. [S. S.]

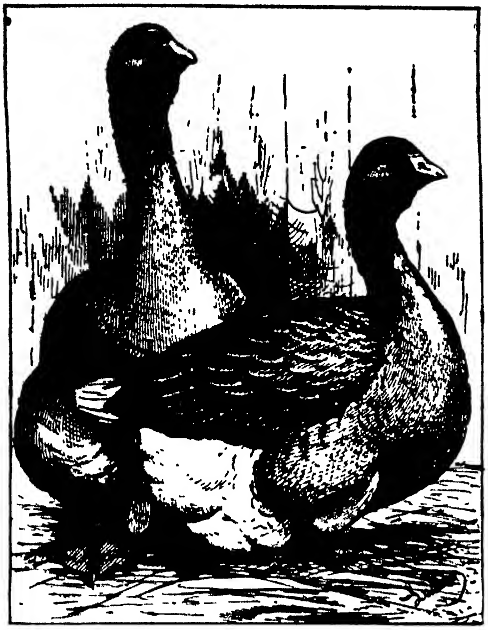
Tormentil. — The common Tormentil, or Blood Root (*Tormentilla* or *Potentilla officinalis*, nat. ord. Rosaceæ, sub-order Potentilleæ), is a familiar plant on moors and heaths in Britain and the greater part of Europe. The large woody root, which contains tannin, gum, and a red colouring matter, has long been esteemed as an astringent. The small bright-yellow flowers are produced in summer; they have four petals, but the lowest on the stem frequently has five. [W. W.]

Tortrix, a genus of small moths, many of which are popularly known as 'leaf rollers', from their habit of curling up the leaves of the plants on which they feed, thus protecting themselves when at work. There are innumerable species of this and allied genera, and hardly any garden plant is free from their depredations. The little active caterpillars so destructive to roses belong to this group.

T. viridana is the well-known Green Oak Tortrix, which in certain seasons entirely defoliates Oak trees over large areas. As with other leaf-eating caterpillars, the best treatment in the case of Tortrix attack is to spray with Paris green or some other arsenical poison (see art. ARSENICAL WASHES). [R. H. L.]

Toulouse Goose.—Though the Toulouse goose originated in France and is still extensively bred in the Department of Haute Garonne, probably much of its size is due to British influences, as it has been bred here to a fixed type and for size. The plumage is largely grey in colour with light stern, paunch, and tail, in which respect it follows its progenitor, the Greylag. It is very massive, deep and long in body, the line of the keel being almost level with or near to the ground. The legs are short and heavy in bone. These birds attain a larger size than the Embden, but are slower in growth, and consequently are not usually ready for killing before Christmas. They respond to good treatment, and appear to require richer lands in order to bring them to a state of perfection, with abundant feeding. They fatten well; but as goose flesh is not nearly so much in demand as was the case at one time, and smaller birds are desired, the special qualities of the Toulouse are not so much in its favour as formerly. These birds will often reach 20 lb. in eight months, and few people want specimens of that size. The geese are good layers, and the eggs laid by them are very large, but the birds are not very reliable for hatching and rearing. Breeding for exhibition has led to development of a dew-

lap on the throat and to a loose paunch, which are by no means improvements, and are apt to promote looseness of skin. [E. B.]



Toulouse Geese

Town Dairy, Regulations for. See DAIRIES, COW SHEDS, AND MILK SHOP ORDERS.

Towns, Trees for.—For planting in the smoky atmosphere of towns, coniferous trees are least suited for resisting the poisonous action produced upon the leaves by the sulphurous acid contained in the smoky atmosphere. The denser the foliage and the longer it persists, the more the evergreen conifers suffer from smoky air. Silver Fir suffers most, then Spruce and Scots Pine, and the deciduous Larch least of all. Thus in the Glasgow Botanic Gardens, conifers can no longer be grown; and even in the less smoky atmosphere at the Edinburgh Botanic Gardens they are now becoming unhealthy.

No hard-and-fast classification can be made as to the suitability or non-suitability of the different kinds of deciduous broad-leaved trees for growing in towns. But experience has shown that, in general, Beech suffers most from town smoke, and Oak, Elm, Sycamore, Robinia, and Plane tree least, especially the hybrid variety known as London Plane (*Platanus acerifolia*); whilst the other trees mostly grown for ornament in parks and gardens, and including Birch, Lime, Alder, Ash, Maple, Poplars, Willows, Horse-chestnut, Gingko, Catalpa, and Ailanthus, occupy intermediate positions between these extremes, though varying, of course, according to the nature of the climate, soil, and situation. For street planting and for town avenues, Plane, Maple, Sycamore, Elm, Lime, and Horse-chestnut are the most suitable; and their growth is improved when large open gratings are put round the tree at ground-level to allow moisture to percolate into the soil, and to provide a certain amount of aeration. In the London parks, Plane, Elm, Sycamore, and Robinia usually thrive best on the whole, then Lime and Ash; while Canadian Poplar does well for about twenty years, and then produces only poor and ragged foliage. Among the more recently introduced trees the leathery-leaved Japanese maidenhair tree (*Gingko biloba*), the Indian Bean (*Catalpa bignonioides*), and the Tulip tree (*Liriodendron tulipifera*) are found to thrive in parks and open spaces, and to be highly ornamental. In the larger towns of Northern Europe the trees chiefly planted in towns are Lime, Elm, Maple, Sycamore, Plane, and Horse-chestnut. Of these the Horse-chestnut is the most beautiful in the flowering time of spring; in summer, Plane and Elm have the best foliage; and in autumn, the Maple shows the richest colouring. In Central Europe the American Horse-chestnuts, the red- and the yellow-flowering Buckeye (Pavia), are largely grown in avenues; but for their full development they need a warmer climate than obtains in most parts of Britain. [J. N.]

Townshend, Lord. — Charles Viscount Townshend, a member of an ancient Norfolk family, was born in 1674. After a political career of great distinction, in which he held many important posts, including that of Prime Minister in the reign of George I, he retired to his ancestral estate at Rainham in 1730. For the remainder of his life he devoted himself entirely to agriculture, in connection with which, it may safely be said, he did more good in the few years that remained to him than he had done in a long career in politics. He at once began to improve the naturally poor and badly neglected soil of his estate. Travels on the Continent of Europe had rendered him familiar with the marling of the land and the cultivation of turnips and clover as field crops. Partly by the former, but far more effectually by the latter, he steadily raised the fertility of his land. The feeding of sheep on turnips and clover was the best of all treatment for the poor light soil of his part of Norfolk. Tull had introduced turnips before Townshend began to grow them; but no one had followed the former in cultivating the crop. Townshend was the first landowner in England to grow it extensively. He adopted for its cultivation Tull's methods of drilling and horse-hoeing (see TULL). His persistent advocacy of the growing of the roots gained him the nickname of 'Turnip Townshend'. He was the initiator of the four-course plan of farming which in course of time made the Norfolk system of husbandry famous all over the world. He died in 1738. [W. E. B.]

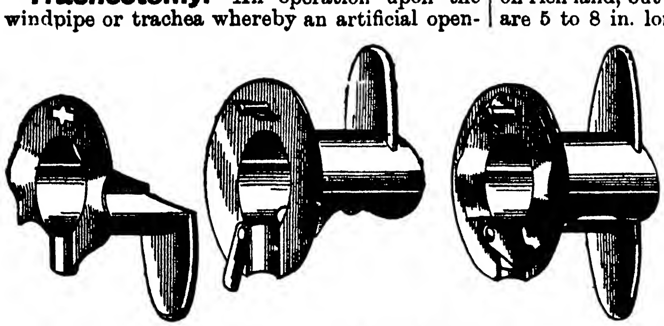
Toxins.—In the strict sense of the term, toxins are poisonous substances produced by the bacteria that cause such diseases as tetanus and diphtheria. These organisms do not themselves spread in the body, but develop complex poisonous compounds that flood the circulation. Their chemical nature is obscure, but their molecules appear to contain two side chains, one of which, called the haptophore group, enables the

toxin molecule to combine with the body cells, and the other, the toxophore group, produces the poisonous effect. Against the action of any specific toxin the organism seeks to protect itself by producing a corresponding antitoxin, which combines with the toxin and thus prevents it from doing its characteristic mischief, unless the toxin present is more than the antitoxin formed can neutralize. By injecting a toxin, *e.g.* tetanus toxin, into a horse in gradually increasing quantities, large amounts of antitoxin are produced, and the serum becomes capable of immunizing other animals against tetanus. The toxin combines with the animal cell by means of side chains attached to the latter which have been called receptors. It is supposed that the injection of toxin in the process of preparing an immune serum causes an increased production of these receptors, and that many of them become detached from the body cells. The liberated receptors are the molecules of antitoxin, which can combine with the toxin and thus prevent these becoming attached to the body cells.

There are certain other poisons, of which the snake venoms are the most important, which have many points of resemblance to the toxins that have been described above, but also present certain important points of difference. The cadaveric alkaloids and other ptomaines are sometimes called toxins, but they differ from the true toxins fundamentally. Like strychnine and the other poisonous vegetable alkaloids they do not combine with the body cells as the true toxins do, and therefore they cannot be antagonized by anti-substances like the antitoxins.

The name of toxins has also been given to certain products that are supposed to be excreted by the roots of plants and to make the soil injurious to succeeding crops of the same species. The existence and action of these substances is, however, to say the least, too problematical to call for their mention here. [C. M. L.]

Tracheotomy.—An operation upon the windpipe or trachea whereby an artificial opening is made, and through which the animal is enabled to breathe, is known by the above name. It is of great value when suffocation threatens through obstruction of the air passage of the larynx (see LARYNGITIS) from inflammation or the presence of foreign bodies. It is also performed for the permanent relief of roarers or whistlers (see ROARING). The most convenient site for operation is about one-third of the way down the windpipe, from the throat to the breast, as here there is the minimum amount of muscular clothing; but some experts prefer to place the tube very high up, and where it is less seen, close to the larynx. The animal owner called upon to act in an emergency may choose the first situation, make an incision 3 in. long, right through the skin, and showing the cartilaginous rings of the trachea. The integument is easily separated on each side for the removal of a circular piece of the pipe, which should be prevented from falling inwards by being first transfixed with a needle carrying a stout thread. When the disk is taken out, a tube of any sort may be temporarily employed while a veterinary surgeon is sought. The hinged and valved tubes invented by Mr. Gibson, M.R.C.V.S., of Oakham, are the best, but simpler and less expensive ones are supplied by instrument makers. Antiseptics should, of course, be employed, but the operation is quite a simple one as performed upon animals. [H. L.]



Tracheotomy Tube (Arnold & Sons)

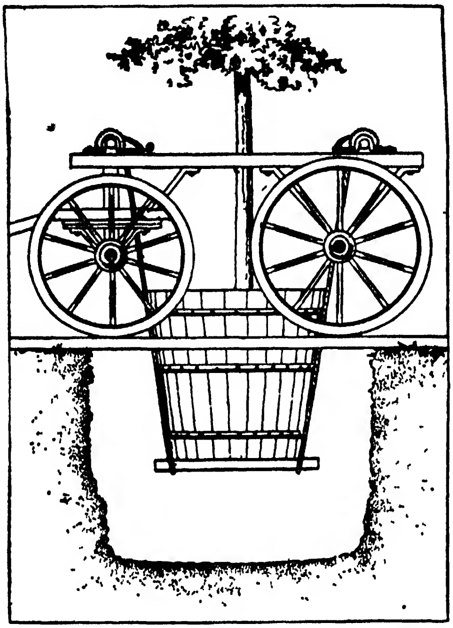
Trachyte, a partly glassy, partly crystalline, igneous rock with the chemical composition of syenite, from which it differs in having cooled more rapidly, usually as a lava at the earth's surface. It is generally light in colour, greyish or whitish, with crystals of clear orthoclase scattered through it. Certain hills south-east of Limerick are formed of ancient trachytes; but the rock is rare in the British Isles. It is common on the Rhine near Bonn, and trachytic ash forms an abundant porous earth in the Brohltal. Trachyte soils are light, dry, and well furnished with potash, of which the undecomposed rock may contain 5 to 6 per cent. [G. A. J. C.]

Tragopogon (Goat's-beard) is the botanical name of a genus of taprooted biennial or perennial composite plants with milky juice sometimes found as reeds in meadows and pastures on rich land, but never troublesome. The leaves are 5 to 8 in. long, narrow and grasslike, with the base broadest and sheathing the stem. The flowers are all ligulate, and arranged in heads surrounded by narrow involucral leaves over 1 in. long. The 'seed' is long and narrow, with a slender beak crowned by a tuft of very feathery hairs (*pappus*). Yellow Goat's-beard (*Tragopogon pratensis*) has yellow flowers; Purple Goat's-beard, or Salsify (*Tragopogon porrifolius*), has purple flowers, and is cultivated as a culinary vegetable. [A. N. M'A.]

Training Horses. See art. BREAKING.

Transplanting, one of the most important and everyday operations in horticulture. Because of the need for economising space, and for other reasons, comparatively few plants are grown from seeds or cuttings in the positions they are to occupy permanently, and if carefully performed transplanting is usually bene-

ficial. The transplanting of seedlings and young plants encourages the formation of roots, and in the case of trees and shrubs grown for sale it is important that it should be performed every two or three years, or else when the time comes for their final removal they will have long straggling root systems, and their transplanting will probably occasion serious loss. Regularly transplanted trees and shrubs offered by reputable firms will cost more, and may not look superior to the untrained eye, but their purchase is sure to prove economical in the end. Transplanting seedlings of vegetables and flowers and herbaceous border plants is usually quite a



Side Elevation of Transplanting Machine for Trees of large size. The mass is raised by means of iron crowbars which fit into sockets in the rollers around which the lifting-ropes are wound.

simple matter, and only requires careful handling and watering, and the provision of some degree of shade afterwards. Transplanting is much best performed in mild, dull, and showery weather, and the new positions for the plants should always have been previously prepared. But such climatic conditions are not to be had for the wishing; it is unfortunately almost the rule to defer transplanting seedlings until they are already rapidly deteriorating for the want of it, and such mistaken treatment cannot fail to have a very bad effect upon the crop. Seedlings transplant best from a somewhat light soil, and that is why seeds are usually sown in it. The transplanting of shrubs and trees of all kinds is a less easy operation, particularly so when they have some distance to travel to the new site. Although more laborious, it is much safer to transplant them with a ball of soil about the roots, but in the case of plants purchased from nurseries the cost of carriage renders this undesirable. Plants received without soil about their roots should be planted immediately, unless the weather or condition of the soil is very unfavourable; and should the roots be dry they must be thoroughly soaked before planting. The time of transplanting is very important. Deciduous trees and plants may be safely moved in open weather from the fall of the leaf till the end of March, autumn being the best time; but magnolias, which are difficult to transplant, are an exception—they should be moved either in October, March, or April. Nearly all evergreens should be shifted in September, or else left till late spring. Bamboos and evergreen oaks are best transplanted in May or June. Care must be taken to injure the roots as little as possible, and any that are bruised should be cut off with a sharp knife. It is preferable that the ground to receive the plants should have been trenched and manured, and some plants—such as those that thrive in peat—may require a special soil mixture. The holes should be made even larger than is necessary to receive the roots laid out to their full extent. Two men are required to transplant even small shrubs efficiently. The soil must be settled in firmly about the roots, and well watered if it tends to dryness. Where many large plants have to be moved, it is best to use a transplanting machine. An illustration of one of the best patterns is appended, and this gives a good idea of the manner in which the operation is performed. [W. W.]

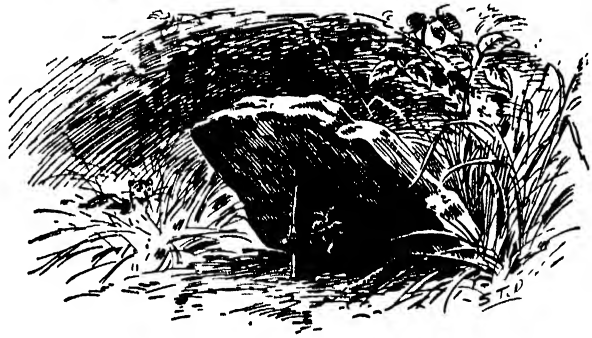
Trapping.—To carry out trapping operations successfully, it is of the first importance to make a careful study of the habits of each species of animal which it is desired to capture. Not only must the accustomed haunts of the creatures be known, but the particular food which each kind will find most seductive as a bait has to be ascertained. In the case of carnivores, it is often very helpful to know their methods of pursuing prey; these animals often proceed in a most systematic manner, 'working through' a district with wonderful thoroughness, and once the trapper has observed their plan of campaign he will be able to set his traps with a much enhanced prospect of success.

Some of the most obnoxious vermin are domestic cats which have turned wild and taken to the woods. They destroy game, and often extend their depredations to the poultry yard. Fortunately they are never suspicious of the presence of traps, and this is much the best method of compassing their destruction, for poisoning is always dangerous. Steel traps should be used, and should be set under brushwood, preferably close to a tree, for the animals often slink from tree to tree when hunting. The traps should be baited with fish—herring being perhaps the best to use. Both pine martens and polecats are now very rare; indeed they have altogether disappeared from a large part of the British Isles. Martens are usually taken in steel traps, baited with birds' flesh, which proves an irresistible attraction to these animals. Where polecats are still hunted it is customary to capture them in box traps, with almost any kind of bait. It is best to lay the

traps in ditches, for polecats, when on the prowl, always make their way along any convenient hollow, in order to conceal themselves. Stoats and weasels are most troublesome pests, and in spite of the vigorous persecution to which they are subjected, they do not seem to be diminishing very greatly in numbers. These little carnivores can travel great distances, and it is thus almost impossible to clear an estate of them altogether. When hunting, they go to work in a most systematic manner, and slink along in ditches or under cover of walls or hedges. Traps should therefore be laid in such situations as these. A hole in a wall is an excellent spot to select, for the weasel is a most thorough little hunter, and is certain to go through the hole in order to survey the land on the opposite side. Small steel traps are generally used, and it is usually found unnecessary to bait them, if they are laid in the situations mentioned. These vermin can be most effectively destroyed in May and June, when they hunt in family parties. If the trapper watches until the old female is caught, and then suspends her dead body over the trap, he will find that the young will walk into the snare one after another until all have perished. Hedgehogs should be taken in traps baited with eggs. See TRAPS FOR VERMIN. [H. S. R. E.]

Trap-rock.—Lavas containing much iron and no excess of silica, such as basalts and basic andesites, flow to considerable distances from volcanic vents, and form extensive sheets across the country. When attacked by weathering, they form scarps perpendicular to their surfaces, particularly when a columnar structure has developed, and successive flows, with their fairly level tops and vertical edges, resemble a series of gigantic steps in a broad landscape. This structure, so conspicuous in Skye and Mull and the outlying Treshnish islets, is styled *trappean*, from a Swedish word meaning a staircase. Gradually such lavas were called 'trap-rocks' or 'traps', and the term came to be applied to them whether in dykes, bosses, or terraced flows. For the characters of typical trap-rocks, see arts. ANDESITE and BASALT. [G. A. J. C.]

Traps for Vermin.—Of all the forms of traps in use for small animals, the most generally serviceable is that known as the 'dead fall'. This consists of a heavy block of stone or wood, which is supported by a trigger of ingenious but easily contrived pattern, called the 'figure-of-four' support. All countrymen will be familiar with this trap, and every gamekeeper will know how to set it. The instrument is inexpensive and effective, and, in appropriate sizes, can be used for all kinds of vermin. For stoats and weasels it should be baited with the entrails of rabbits; the bait is attached to the wooden trigger, and when the little carnivore pulls at it, the precarious support gives way and the stone crashes down, flattening out and killing the animal instantaneously. It is a humane method of putting an end to the creature's existence, since there is no lingering death. (For the best situation in which to set the traps, see TRAPPING.) The dead fall can be made large enough for killing cats. Rabbits are often great pests to farmers, but (although, perhaps, shooting is the best method of destroying them) they are generally snared in large numbers by a simple and cheap contrivance. A wooden peg is driven into the ground over a rabbit hole or by a run in the hedgerow. From this a wire projects, and is twisted on itself to form a noose about 1 ft. in circumference, and having a ring at the end, which will run freely along the wire. This is the ordinary snare. It is made much more humane by the following contrivance. Five and a half inches from the end of the wire a small ring is tied to the wire by a simple knot. When the rabbit runs his head unthinkingly and with some force into the noose, it is of course pulled



Dead Fall

tight as far as this knot. The noose, which is now only $5\frac{1}{2}$ in. in circumference, is securely around the creature's neck, and he cannot possibly get his head out. On the other hand, there is no painful throttling process, for owing to the second ring the noose cannot be drawn any tighter. The animal merely sits in the painless snare till the trapper goes his rounds, and experience shows that, after the first few moments in the noose, the captives struggle but little. This variety of trap was first tried with a knot only—with no second ring. Thus constructed it proved a failure, but now that the ring has been introduced the snare should be widely adopted. Wire-cage traps, if set in such places as ditches, along which stoats and weasels are wont to steal, are very effective. The best sort are those which have spring doors at both ends, so that they can be left open for several days in order that the animals may grow accustomed to walking through them. If they be then baited with flesh, they are sure to secure the first carnivore which comes along. The familiar steel trap, or gin, is an extremely cruel instrument, though very widely used. When traps are employed, the trapper should visit his gins at very short intervals, in order to terminate as quickly as possible the agony of his captives. [H. S. R. E.]

Tree Creeper (*Certhia familiaris*).—This small perching bird may often be seen climbing

up trees and walls in search of insects, of which its food entirely consists. The stiff tail serves as a support, and the slender curved beak is well adapted for probing crevices in the bark. The upper side of the body and wings is brown, spotted and streaked with white, and the under side is buff-coloured. The nest is built of moss, roots, and feathers, either in a hole in a tree trunk, or in a gap formed by the separation of the bark. The six to eight white eggs are marked with red spots at the broad end. Of no importance agriculturally, the bird is extremely beneficial to forestry and fruit culture, destroying

Tree Creeper

noxious insects in all stages of their existence from the egg onwards. [J. R. A. D.]

Tree of Heaven, a tall, rapidly growing tree, often planted as a shade tree in parks and public places. See AILANTHUS.

Trees, Sylvicultural Characteristics of, are: (I) their special peculiarities regarding climate, soil, and situation; light and shade; shape of root system, stem, and crown; rate of growth; reproductive and regenerative power; and maturity and longevity; and (II) their general characteristics as woodland crops, in consequence of these special peculiarities.

(1) *As regards climate,* all kinds of trees have northern and southern limits determined by winter cold and summer heat or drought, and also limits of altitude in mountainous tracts determined by cold. Owing to geographical conditions and local configuration, there can never be hard-and-fast lines of demarcation throughout Western Europe; but the northern limit of the chief forest trees is for Silver Fir about 52°, Beech 60°, Pedunculate Oak 63°, Scots Pine 70°, and Spruce 71°. In Eastern Europe (Russia), however, these limits are reduced considerably, except in the case of Oak; while the southern limits vary greatly, according to the amount and the regularity of the summer rainfall.

(2) *As regards temperature and rainfall,* the mild equable climate of Great Britain is exceptionally well suited for all the woodland trees of Central Europe; and many of the North American trees thrive far better here than on the Continent. But of our common woodland trees, experience shows that Birch, Scots Elm, and Scots Pine grow better in Scotland than in England; that Beech, English Elm, Pedunculate Oak, Chestnut, and Weymouth and Maritime Pines do best in the warmer parts of England; that Alder, Ash, Pedunculate Oak, English Elm, Maple, Willows, and Poplars thrive best on low-lying land; and that Scots Elm, Sessile Oak, Sycamore, Scots Pine, Spruces, Silver and Douglas Firs, and Larch do best on hilly land. Beech, Ash, Chestnut, Robinia, and Silver and Douglas (Pacific) Firs are most liable to damage from frost; while Aspen, Birch, Elm, Hornbeam, Lime, Sallow, Larch, and Spruce are the hardiest against winter cold; though all kinds are more likely to be nipped by late frost when growing on land exposed to the early morning sunshine. Elm, Oak, and Larch do best in a fairly dry climate, and Alder, Ash, Maple, Sycamore, Willow, and Poplar in a fairly moist.

(3) *As regards soil and situation,* conifers generally are less exacting and have a greater accommodative power than broad-leaved trees in respect to moisture and mineral food, the most accommodative trees being Aspen, Birch, Sallow, and Scots Pine, and the least accommodative, Ash and English Elm. Depth, permeability, and a moderate amount of moisture are of more importance than any particular kind of soil; for it is of greater physiological advantage that the root system of any tree should develop freely and normally, and that the situation should (as regards climate, natural drainage, aspect, &c.) be suitable, than that the soil itself should be of a sandy, a loamy, a clayey, or a limy description. With satisfactory physical properties (depth, permeability, moisture, and temperature) any kind of soil may be relied on to furnish sufficient mineral food for good tree growth; but Oak, Ash, Elm, Chestnut, Maple, Sycamore, Larch, Douglas and Silver Firs, and Scots Pine have the deepest roots, and therefore need the greatest depth of soil for good growth; while Aspen, Birch, Willow, Poplar, and Spruce have only a shallow root-system (though they, too, grow better on a deep than in a shallow soil). Beech, Ash, Elm, Maple, Sycamore, Hornbeam, White Alder, Oak, Austrian Pine, and Larch thrive well on soil containing a good deal of lime, but this seems to act injuriously on Sweet Chestnut, Douglas Fir, and Maritime Pine. Humus or leaf-mould improves all kinds of soil, and hence replantation on true 'woodland soil' is usually more successful than the first planting of waste lands and poor pastures (probably owing to a deficiency of nitrogen in an easily available form).

(4) *As regards light and shade,* trees are classifiable as *light-demanding* and *shade-enduring,* according to the amount and the intensity of the sunlight needed for assimilation and sap-elaboration—the demand being apparent from the amount of foliage borne by the tree-crown (which, of course, varies with the situation and

the quality of the soil). The light-demanding trees most impatient of shade are Larch, Birch, and Robinia; Pines, Poplars, and Willows; Oak, Ash, Elm, and Chestnut; less impatient of shade are Alder, Lime, Horse-chestnut, Maple, and Sycamore; while Beech and Hornbeam, and most evergreen conifers (especially Spruce, Douglas and Silver Firs, and *Thuja gigantea*), are shade-enduring, as also the stool-shoots of the kinds of trees usually grown as underwood in copses. All our woodland trees thrive best when their crown of foliage is freely exposed to sunlight; but Beech and Silver Fir seedlings need protection against frost for the first two or three to four or five years.

(5) *As regards root system, stem, and crown*, trees grown as woodland crops are always confined in a smaller growing-space than when standing freely in the open; but while the roots and the crown are kept smaller, the growth in height (due to the struggle for existence) is greater, and there is less tendency to spread sidewards into branches. And, of course, it is only when deep-rooting and light-demanding kinds of trees have their natural requirements satisfied that good growth can be maintained, and more especially as the trees approach maturity.

(6) *As regards rate of growth* as timber crops, few of those which grow rapidly in height at first furnish very large mature crops, though the Pacific variety of Douglas Fir is an exception in this respect. The next largest crops per acre are yielded by Silver Firs and Spruces, which are both slow in establishing themselves and beginning to shoot ahead.

(7) *Reproductive and regenerative power* are different forms of utilizing nutrient reserves for propagation of the species, reproduction being achieved by stool-shoots and root-suckers (see COPPICE), and regeneration by seed. Trees bearing small fruits with tiny seeds are much more prolific than those bearing large and heavy fruits, and they seed more frequently, and are spread farther by wind; hence, even though the germinative power of the seed be less, the average regenerative power of Aspen and other Poplars, Alder, Birch, Scots Elm, Maple, Sycamore, Willows, Pines, Spruces, Douglas Fir, and *Thuja gigantea* is greater than in Silver Fir, Beech, Oak, and Chestnut.

(8) *Maturity and longevity* vary greatly in our woodland trees (up to about 500 years, and more, for Oak and Chestnut); but timber crops reach their marketable or financial maturity at a comparatively early age, and earlier on poor than on good soil, varying from 40 to 70 years for conifers, 35 to 50 years for softwoods, 60 to 100 years for most hardwoods, and 100 to 150 for Oak. Thus two or three conifer crops may be taken for one of Oak; and this is one of the great advantages promised by growing conifer trees suitable for any given soil and situation.

In consequence of the combined influence of the above-mentioned special peculiarities, trees are either gregarious in habit, and then found forming large and more or less pure forests; or else sporadic, and then found scattered singly or in patches and groups mixed along with other trees. Other things being equal, shade-enduring trees would gradually, in course of time, oust light-demanding trees, and become ruling species over large areas; as, for example, where the Silver Fir, the Beech, and the Spruce form large forests in Central Europe. But other things are never equal in nature; and trees having light and winged seeds, especially those hardy kinds of trees that grow quickly at first (*e.g.* Birch and Aspen), often establish themselves securely before the kinds previously on the ground have been able to regenerate themselves (see MIXED WOODS), so that a mixture of trees varying according to soil and situation is characteristic of all natural woodlands, and is the safest pattern to copy in forestry. [J. N.]

Trefoil, a common name for Black Medick, Nonsuch Clover, or Yellow Trefoil; a species of

Trefoil (*Medicago lupulina*)

Medicago (which see). It is sometimes referred to by farmers as 'Hop' or 'Hop Trefoil', but this term should be abandoned as likely to be confused with Hop Clover (*Trifolium procumbens*, L.), a wild plant frequently found on dry soils.

Trefoil is an annual or biennial plant grown chiefly on calcareous soils for the feeding of sheep and lambs. It yields a fair amount of nutritious fodder on soils which do not grow many green crops successfully, and the seed is cheap. It is ready for use in spring ten days or a fortnight earlier than Red Clover.

When sown alone the seed is broadcasted on young corn in spring, at the rate of 20 lb. per acre, and covered by a light harrowing.

Trefoil is extensively used as a constituent of mixtures of clover and grass seeds for temporary pastures. It provides good 'bottom' herbage during the first year or two of the ley, but on account of its short life it should not be used in excessive amounts for pastures to be kept down more than two or three years, as it is liable to smother out the more lasting plants, and when it dies out leaves bare patches which become overrun with weeds. [J. P.]

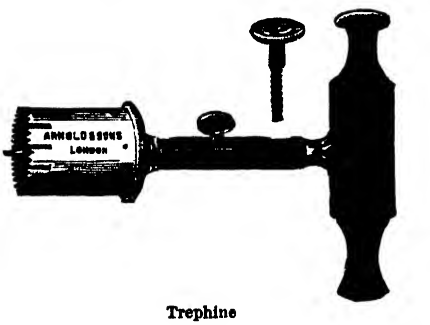
Trellis, an arrangement of supporters on which to train garden plants. A framework of wires fixed near the glass in greenhouses is necessary for the training of such plants as vines, peaches and nectarines, melons and cucumbers; wire trellises, usually pyramid or balloon-shaped, are fixed to large pots containing Stephanotis, Lapageria, and other climbers; and there must be some sort of treillage for the support of espalier fruit trees which are not planted by a wall. Espalier trellis made of iron rods is neater and more durable than wood, but plants do not thrive so well in contact with metal outdoors, as metal is so extremely susceptible to

extremes of temperature. The popular pergola is often a trellis of a kind, and delightful effects can be produced, when discrimination is used, by training climbers over a trellis. [W. W.]

Trembling, a disease of sheep characterized by nervous spasms of the limbs and neck. See LOUPING ILL.

Trenching, or **Trench Ploughing,** sometimes called double ploughing, consists in bringing up the subsoil by means of a special implement, and throwing it over a shallower first furrow. The trench plough follows in the wake of a strong plough, and each is drawn by a team of four horses—the cultivation being about 15 to 19 in. in depth. It may be accomplished at one operation, by a specially constructed plough, capable of turning a furrow, sometimes of 3 ft. deep. In such cases steam power is almost a necessity. Trench ploughing must not be confused with subsoiling, which only aims at breaking the subsoil without bringing it to the surface. In the case of shallow soils, or soils underlaid by a sour or unoxidized subsoil, no good effect could follow the mixing of the bottom and the top soil together. Trench ploughing should only be attempted upon deep soils in which the soil and subsoil are of the same nature, or of such a character that the blending of the two will be beneficial to both. The operation may do much harm, or much good, according to circumstances, but is rarely attempted excepting upon deep and rich soils. As a preparation for hops, liquorice, potatoes, celery, rhubarb, asparagus, and other plants which revel in a deep soil, it is to be highly recommended, and may pay well. Indiscriminate deep cultivation of this kind, however, should not be attempted on thin soils, and it is doubtful if it is adapted for cereal cultivation, unless indirectly, *i.e.* in previous years. [J. WR.]

Trephining, an operation performed with a circular saw or other instrument for the removal of a disk of bone. The stock trephine is



Trephine

made on the same principle as the joiner's, the hand trephine being less powerful. Bone elevators, chisels, and periosteum knives are made to fit into the stock, and are interchangeable. Trephining is practised for the removal of injured bone, or relief of compressed tissues, and to gain access to cavities otherwise sealed. The trephine is most often used in the treatment of abscess in the facial sinuses; in gleets, with a necrosed bone as their cause; in morbid conditions of the bone excited by diseased teeth, and from injuries by foreign bodies, as splinters and bullets. Trephining is often practised with success for the purpose of destroying hydatids on the brain, or even in its substance, if not too deeply situated. In using the trephine, care must be exercised in not applying too much pressure, especially when the bone is nearly divided; and it may be best for the amateur to lift out the disk of bone before the whole circumference has been sawn through. For a sheep worth no more than thirty shillings it does not pay to send a long distance for a surgeon, and so many flockmen have learned to perform this useful operation themselves. [H. L.]

Trespass.—1. ENGLAND.—In English law, trespass may be to land, to goods, or to the person; but this article only deals with trespass to land, whether by man or animals. The essence of the offence is the breaking and entering on the land, and in strict law damage may be claimed for the mere unwarrantable entry although no damage be done; but if there be injury to the premises, reparation may be got for the loss sustained. Trespass may be done by actual bodily entry, or constructively by putting materials or rubbish on the land of another, or by allowing water, filth, &c., to flow on to the lands of another.

Apart from the statutory offence of trespass in pursuit of game, which subjects the trespassers to criminal liabilities (see GAME LAWS), trespass is not a crime, and entails only civil, not criminal, consequences, although trespass accompanied by wilful injury to property may be punished as a crime under the Malicious Injuries to Property Act. The notice board with the legend that 'Trespassers will be prosecuted' is a vain threat owing its origin to the fact that, under certain Statutes, if the damages recovered for the trespass were less than 40*s.* no costs followed, unless the trespass was wilful and malicious, which it was held to be if committed in spite of express notice.

No one is a trespasser if he is on the lands in the course of lawful business, by leave of the occupier, to escape urgent danger, or to recover his property. It is also said that a man is entitled to go on to his neighbour's property to abate a nuisance, but in all such cases it would be much better to appeal to the Court than to take the law into one's own hands. It is, however, a trespass to go on to the lands of others for purposes of sport, *e.g.* foxhunting, unless permission has been granted, although as a matter of common practice no objection is usually taken.

The remedy of the occupier is twofold: (1) to remove by force a trespasser who refuses to leave after being requested to do so. But only sufficient force must be used; and if a trespasser is removed with unnecessary violence he may proceed against the occupier for assault. (2) The occupier may sue for damages for the unlawful entry on his lands, and even if no damage be done he may recover nominal damages. In addition he is entitled to recover damage done to crops, pasture, &c. In the case of trespass by

animals, they may be distrained damage feasant in security of the claim for damage done (see under CATTLE STRAYING; POUND). And whether distress has been done or not, an action for damages lies against the owner of the animals. Where the trespass is likely to cause great damage, the Court will intervene by injunction to prevent it. An action for trespass to land must be instituted within six years after the cause of the action.

A person who is injured on lands on which he is trespassing has, as a rule, no action against the owner or occupier, who owes no duty to him. Thus where a member of the public, taking without the owner's permission a short cut through a field in which a savage horse was kept, was injured by the animal, it was held that the farmer was not liable, on the ground that no duty on the part of the owner of a savage animal to take care that the animal shall not injure him exists towards a trespasser on the land on which it is kept, although the owner knew that the public habitually trespassed on his land, and also knew that the animal was savage, such animal not being kept for the purpose of attacking trespassers. But by Statute it is unlawful to set spring guns, man traps, or other engines calculated to destroy human life or inflict grievous bodily hurt on a trespasser or other person coming in contact therewith, though the setting of any gun or trap such as is generally set with intent to destroy vermin is not thereby rendered illegal. Moreover, it is quite lawful to set a spring gun or other engine in a house for the protection thereof in the nighttime.

2. SCOTLAND.—The term 'trespass', which was unknown in early Scots law and has been borrowed from England, has a more restricted significance in Scots law than in English, since it denotes merely the temporary entry upon the property of another by man or animals. Trespass by animals will be dealt with under WINTER HERDING ACT. Apart from the statutory offences to be referred to later, trespass is a civil wrong, not a criminal offence; but wilful destruction of, or damage to, property is punishable criminally as malicious mischief.

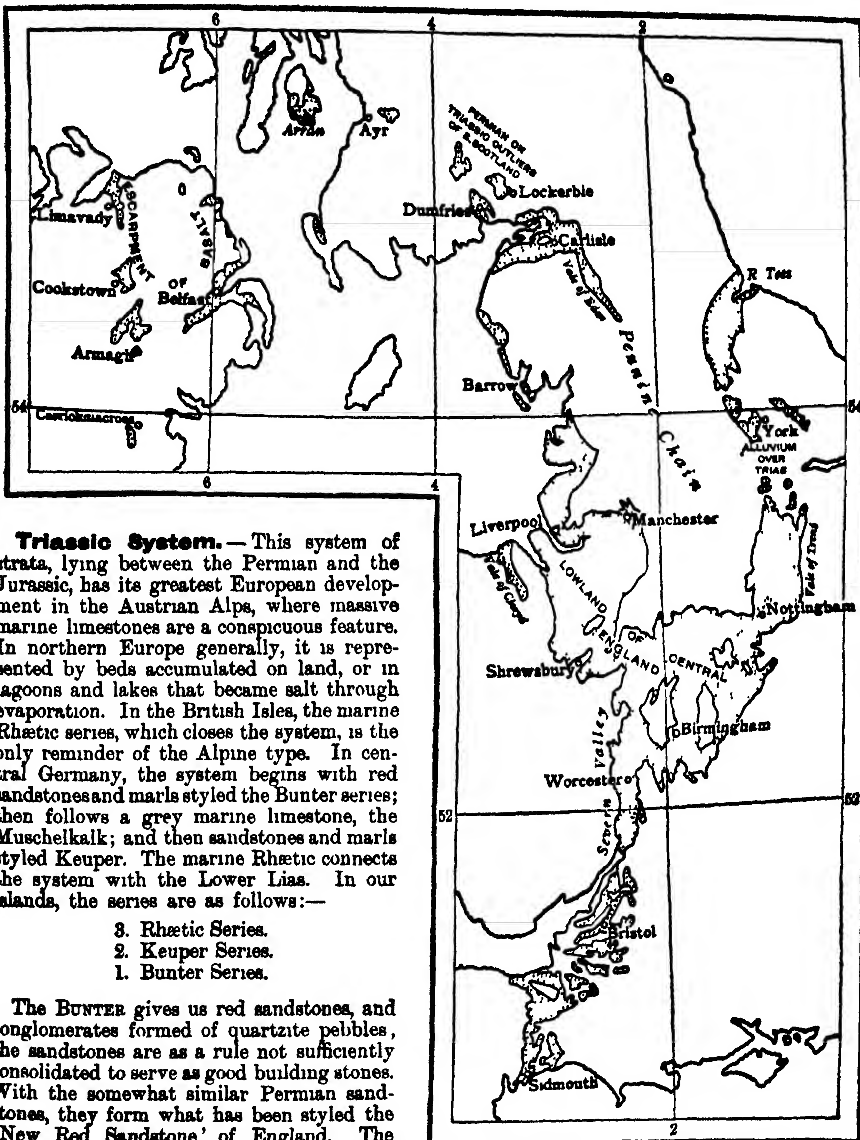
No trespass is committed if the lands of another are entered, without his permission, for the purpose of extinguishing fire, to prevent a crime or in pursuit of a criminal, to escape urgent danger, or in defence of one's goods or stock unlawfully taken or recently straying on to the lands. To this may be added that farmers in a pastoral district are entitled to enter the lands of others in pursuit of foxes, if their destruction is necessary for the preservation of sheep or other animals, provided the good of the public, and not mere amusement, was the motive for the entry.

The owner of the land which has been invaded is entitled to order the intruder off, and to indicate the line he must take in leaving. Where the trespasser is checked on the borders of the land on attempting to enter, or where the trespass is accompanied by acts of violence or such threats as would put the interrupter in fear of bodily hurt, force may be used to repel the trespasser; and it has even been said in one case that if a trespasser persists in refusing to leave, after being requested to do so, he may be ejected by force. But in any event, as in England, if unnecessary violence is used to eject a trespasser, there would be grounds for a charge of assault. This statement, however, does not apply to the invasion of a dwelling-house; and in the case of housebreaking, the occupier of the house is entitled to use force to check and to arrest the housebreaker, and in exceptional cases homicide has even been held justifiable. The only remedy available to the owner of lands on which trespass without damage has been committed, is that of interdict. This remedy is after all somewhat limited in its value, for it will not be granted unless a complainer can prove a reasonable likelihood of a repetition of the trespass. If, however, the complainer is able to prove reasonable grounds for believing that the offence will be repeated, interdict will be granted, unless some public or servitude right is alleged; and in the event of decree being granted, expenses will be given against the trespasser. If thereafter the trespass is repeated, it is in contempt of Court and the trespasser may be severely dealt with according to the gravity of the contempt. In addition to the civil right to an interdict in the circumstances above stated, the owner or occupier of the land on which the trespass has been committed has always an action of damages against the trespasser for any actual injury done, as, for example, by the breaking down of fences or the trampling of growing crops.

The Statute prohibiting the setting of spring guns, &c., above referred to, does not extend to Scotland, as it was considered that the common law of Scotland made such engines clearly illegal; and in the only case which is reported in that country, it was laid down that the placing of a spring gun to shoot trespassers was indictable as murder if death ensued, even although there was no design against any particular person. But, as in England, such engines are permissible for the protection of a house in the nighttime.

In two cases trespass has been made a statutory offence, viz.: (1) trespass in pursuit of game (see under GAME LAWS), and (2) under the Trespass (Scotland) Act, 1865. This Act was passed principally to put a check on travelling tinkers, gipsies, and others from squatting without permission on private properties or private roads. The third section of the Act provides that 'Every person who lodges in any premises, or encamps on any land being private property, without the consent and permission of the owner or legal occupier of said premises or land, and every person who encamps or lights a fire on or near any private road or enclosed or cultivated land, or on or near any plantation, without the consent or permission of the owner or legal occupier of said road or land or plantation, or on or near any turnpike road, statute labour road or other highway, shall be guilty of an offence punishable as hereinafter provided'. Section 4 enacts that offenders, if found in the act of committing the offence, may be apprehended by any officer of police or constable, and shall be at once brought before a magistrate, the

penalty for the first offence being a sum not exceeding 20s., or imprisonment not exceeding 14 days; and for a second or subsequent offence, a penalty not exceeding 40s., or imprisonment for a period not exceeding 21 days. Section 5 provides that the prosecution must be commenced within one month after the offence has been committed. [D. B.]



Sketch Map of Triassic System

Triassic System.—This system of strata, lying between the Permian and the Jurassic, has its greatest European development in the Austrian Alps, where massive marine limestones are a conspicuous feature. In northern Europe generally, it is represented by beds accumulated on land, or in lagoons and lakes that became salt through evaporation. In the British Isles, the marine Rhætic series, which closes the system, is the only reminder of the Alpine type. In central Germany, the system begins with red sandstones and marls styled the Bunter series; then follows a grey marine limestone, the Muschelkalk; and then sandstones and marls styled Keuper. The marine Rhætic connects the system with the Lower Lias. In our islands, the series are as follows:—

3. Rhætic Series.
2. Keuper Series.
1. Bunter Series.

The Bunter gives us red sandstones, and conglomerates formed of quartzite pebbles, the sandstones are as a rule not sufficiently consolidated to serve as good building stones. With the somewhat similar Permian sandstones, they form what has been styled the 'New Red Sandstone' of England. The Keuper Series, beginning with sandstones and coarse talus-deposits, the Triassic 'breccias', closes with red and variegated marls, and this series has been called 'New Red Marl'. The breccias in the south-west of England, as in the Mendip area, are formed of fragments from the Carboniferous Limestone, on the slopes of which they arose; and here an unusually calcareous type of Keuper has been formed. This is known as the *Dolomitic Conglomerate*, since the blocks of limestone have been dolomitized. In Worcestershire, Staffordshire, and Cheshire, the Keuper marls include valuable beds of rock-salt. The salt is now raised as brine. Beds of gypsum occur in the same strata. Owing to the extensive mining and brine-pumping, the lands round Droitwich, Nantwich, Northwich, &c., are liable

to considerable surface sinkings, and in some places houses are built in timber frames, so as to minimize the effects of strain. The term 'wich', so common as a termination in the local names, signifies a place where salt is worked.

The Rhætic Series (Penarth Series of England) appears as beds rarely 50 ft. thick, which are seen at intervals from the Severn estuary to Lincolnshire, and which pass up into the Jurassic strata. They consist mostly of marine limestones and marls. They may be traced as far west as the Triassic outcrop near Limavady in Co. Londonderry.

Though the Bunter pebble-beds form hummocky country, the Trias of England, easily worn away by denudation, has furnished in most places a lowland, which is a conspicuous feature of the midland counties. When we cross westward from the scarp of Jurassic limestones that runs across the country, we see below us what appears to be an immense plain, the nearer part of which is formed of Liassic beds and the farther part of Trias, extending to the Malvern Hills, the Pennine Chain, or even to the sea at Liverpool. The Trent keeps to Triassic strata in its course from Staffordshire through Nottinghamshire to the Humber; and the gypsum dissolved in its waters is said to beneficially affect the ales of Burton. Inliers of more hilly character, such as Charnwood Forest and the midland coalfields, break the lowland here and there; and the Carboniferous uplands of the Pennine Chain divide the plains of York, Doncaster, and Newark, from those of Cheshire. The agricultural value of the Triassic country early favoured the growth of market-centres in it; the ground was suitable for through-routes and communications; and many of the most notable English towns have arisen on its surface. From Newark to Darlington and Rugby to Chester, the Roman roads and the modern railways have taken advantage of Triassic country. Even the fertile plain of York, largely occupied by alluvium, owes its lowland character to the denudation of the Keuper marls and sandstones. Such towns as Manchester, Wolverhampton, and Birmingham, closely dependent on the neighbouring beds of coal and iron-ore, have none the less developed within the Triassic area.

The sandstones of Dumfries and the valleys of the Nith and Annan, until recently regarded as Permian, have now been correlated by the Geological Survey with the Trias. Researches in 1909 on the fossil footprints found in them tend, however, to show their connection with Permian times (see sketch map). Across the Solway, a large part of the fertile Vale of Eden, lying between barren Carboniferous Sandstone hills, has been excavated in Keuper strata, though these are now covered near Carlisle by as much as 200 ft. of glacial drift.

A small area of reddish sandstone on the coast east of Elgin shows that the Trias had at one time a greater northerly extension. This region is famous for the remains of early reptiles.

In Ireland, Trias of the English type occurs, including Rhætic beds in places; but it has been preserved, with the exception of a few outliers, only in the neighbourhood of the basaltic outpourings of the north. Soft sandstones, and marls with rock-salt and gypsum, are exposed as a lowland along the north-west side of Belfast Lough, and similar beds crop out under the basalt scarp at various points round the coast to Lough Foyle. In Glenariff in County Antrim and at Moneymore in County Londonderry, the Triassic lands, with their red soils, present a marked contrast to the more rugged ground that forms the neighbouring heights. Gypsum is obtained from a Triassic outlier as far south as Carrickmacross and Kingscourt.

[G. A. J. C.]

Triassic Soils. — Generally speaking, these soils are reputed to be amongst the most productive in the kingdom. Those of the Lower Trias, or Bunter Series, however, do not reach this pre-eminence. At Cannock Chase, in Staffordshire, for instance, the soils derived from the local conglomerates are gravels of the poorest description, while at Sherwood Forest the land consisting of red or yellow sands can only be regarded as waste. Also the soils derived from the micaceous sandstones of the Lower Keuper are light, poor sands which scarcely repay the expense of cultivation, but which produce pastures good for sheep. Various forest trees, particularly Birch, do well on this formation.

On the other hand, the great fertility of the soils of the Upper Keuper deposits is the outstanding agricultural feature of the Triassic System. These soils are usually rich friable marls or clays possessing a characteristic red colour, highly fertile, and suitable alike for tillage, meadowing, or pasture. There occasionally occur soils of a lighter description which have been derived from intercalated sandy beds. The soils of this series are typically developed in Somersetshire and Devonshire, where turnips or beans and wheat can be grown with equal success. In these counties the application of lime has a very decided effect on the quantity of the crops which can be grown. The whole of the east side of the celebrated cheese-producing county of Cheshire is situated on this formation, and the fertile Vale of Evesham is divided between the New Red Marl and the Lias deposits. A fair proportion of the lands of the Upper Keuper is under the plough, but the more clayey of them are allowed to remain in grass, which they produce in abundance and of excellent quality. Many of these soils are improved by marling; that this fact was recognized by past generations of farmers is sufficiently evident from the number of old marl-pits to be seen, notably in Staffordshire, Cheshire, and Somersetshire. Orchard fruit-trees do particularly well on the red soils of this series, and the cider produced on the New Red Marl deposits, as in the Vale of Taunton, in Devonshire, rivals that from the best cider districts of the Old Red Sandstone formation.

To procure a water-supply on the Keuper marls, it is necessary to bore into the underlying Bunter sandstone beds. [T. H.]